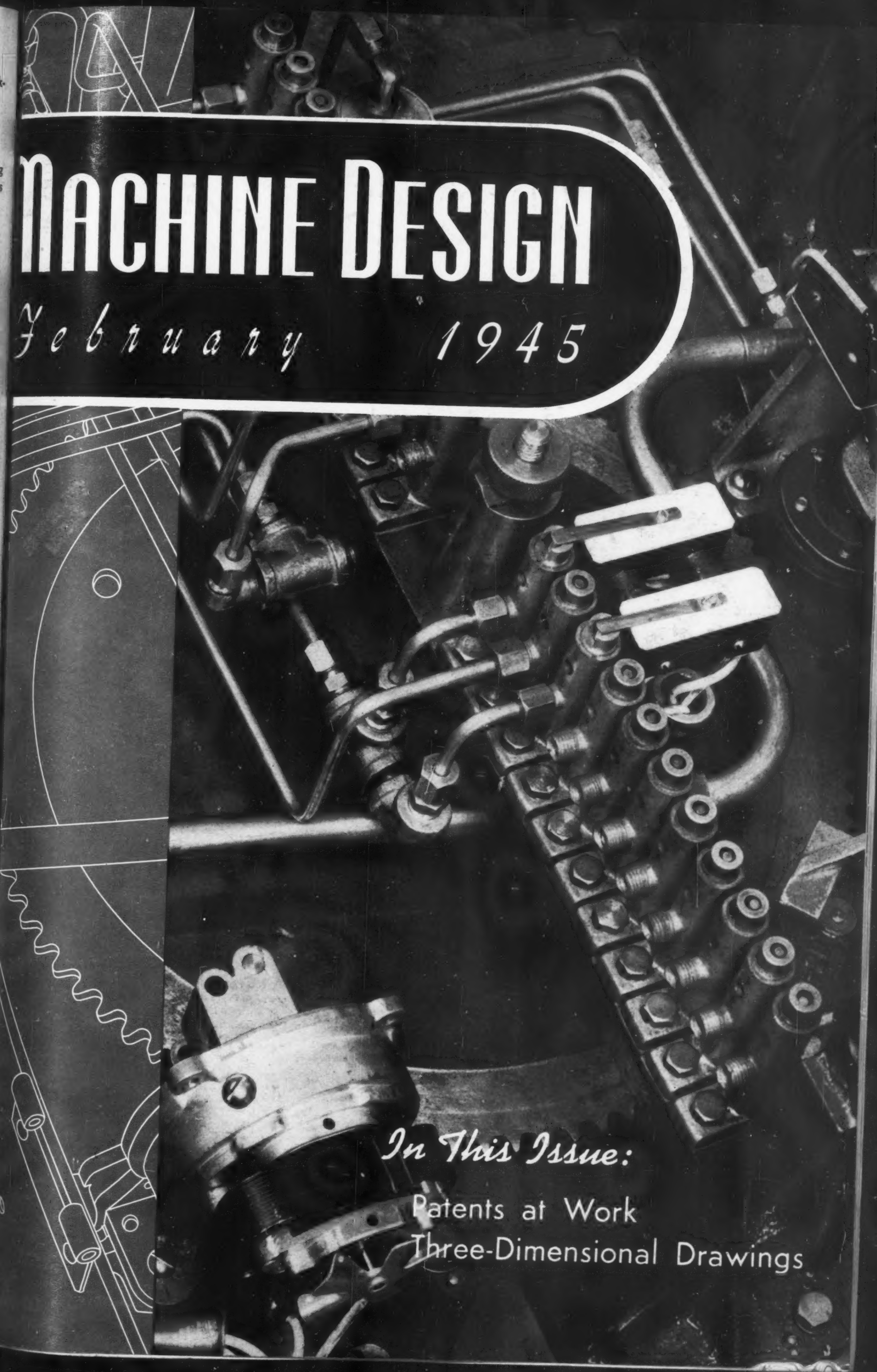
MACHINE DESIGN

February 1945



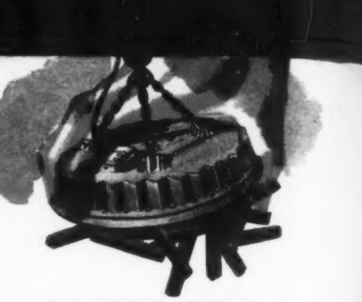
In This Issue:

Patents at Work

Three-Dimensional Drawings

Use MAGNETICS

to move iron and steel
to engage machine members
to stop and hold loads
to protect materials and processes

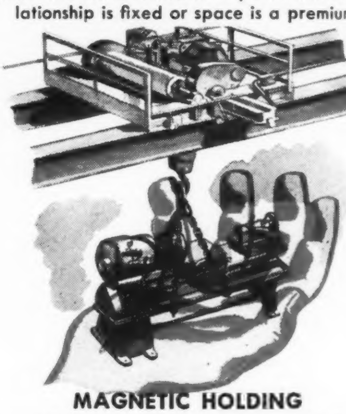


MAGNETIC LIFTING

Do you want to solve a problem of lifting and handling bagged, boxed or bare iron and steel parts? Then look for an answer in the Cutler-Hammer line of lifting magnets . . . every type, from 5 inches up to 6 feet in diameter.

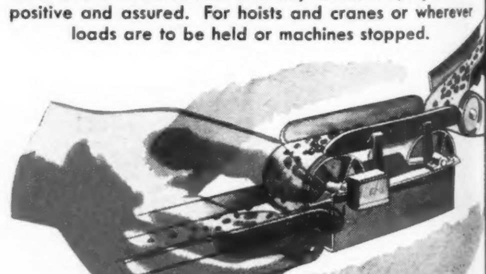
MAGNETIC CLUTCHING

To start and stop machines smoothly, automatically, investigate C-H Magnetic Clutches. All mechanical clutch functions plus many extra advantages. Remote control by pushbutton or automatic means. Superior where speed relationship is fixed or space is a premium.



MAGNETIC HOLDING

Where machines must be stopped, automatically, quickly, without a jar, use a C-H Magnetic Brake. Pushbutton or automatic control. Action smoothly cushioned, operation positive and assured. For hoists and cranes or wherever loads are to be held or machines stopped.



MAGNETIC SORTING

To keep materials in process free . . . to protect valuable machinery . . . from stray pieces of iron or steel, use a Cutler-Hammer Magnetic Separator. Can be installed as part of continuous conveyor line. Valuable in salvaging scrap from refuse, etc.

MAGNETIC "POLICING"

To keep airplane landing fields, parking facilities, roads, rights of way free of chunks and pieces of iron which might rip tires to shreds and endanger lives, use reliable C-H special-purpose magnets mounted on trucks or cars.

Magnetics is an all-round servant whose capabilities may exceed what you imagine, whose functions may be used to great advantage in your production or handling processes.

Conventionally, magnetics may be used to start and stop, engage and disengage machine members at the touch of a button. Magnetics may be used to stop and hold immovable, heavy loads whenever electric current to a motor is shut off. Magnetics may be used to handle iron and steel parts, scrap, assemblies more rapidly, easily and economically than perhaps you ever dreamed. Magnetics may be used to protect materials in process from contamination, machines in operation from damage from stray bits and pieces of iron and steel. Magnetics may be used to keep airplane landing strips, roads, rights of way free of jagged, destructive scraps of iron. The application of magnetics is broad. Why don't you see if magnetics can't help *you*? Submit your problem to Cutler-Hammer magnetics experts. CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

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CUTLER-HAMMER
MOTOR CONTROL
C-H

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

FEBRUARY, 1945 Volume 17—Number 2

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MAIN OFFICE: The Penton Publishing Co., Penton Building, Cleveland 13.

BRANCH OFFICES: *New York* 17, 16 East 43rd St., *Chicago* 11, 520 N. Michigan Ave.; *Pittsburgh* 19, Koppers Building; *Detroit* 2, 6560 Cass Ave.; *Washington* 4, National Press Building; *Los Angeles* 4, 130 North New Hampshire Ave.; *London S.W.* 1, 2 Caxton St., Westminster.

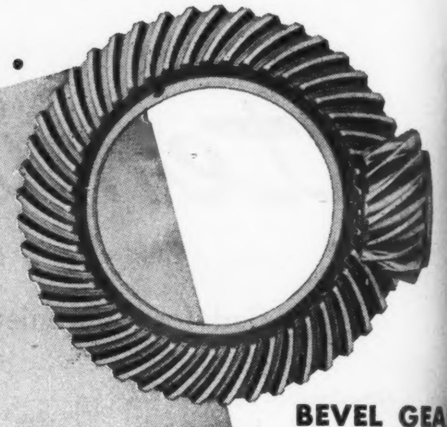
PUBLISHED BY The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on seventh of month. Subscription in U.S. and possessions, Canada, Cuba, Mexico, Central and South America: Two years, $10; one year, $6. Single copies, 50 cents. Other countries: Two years, $14; one year, $8.

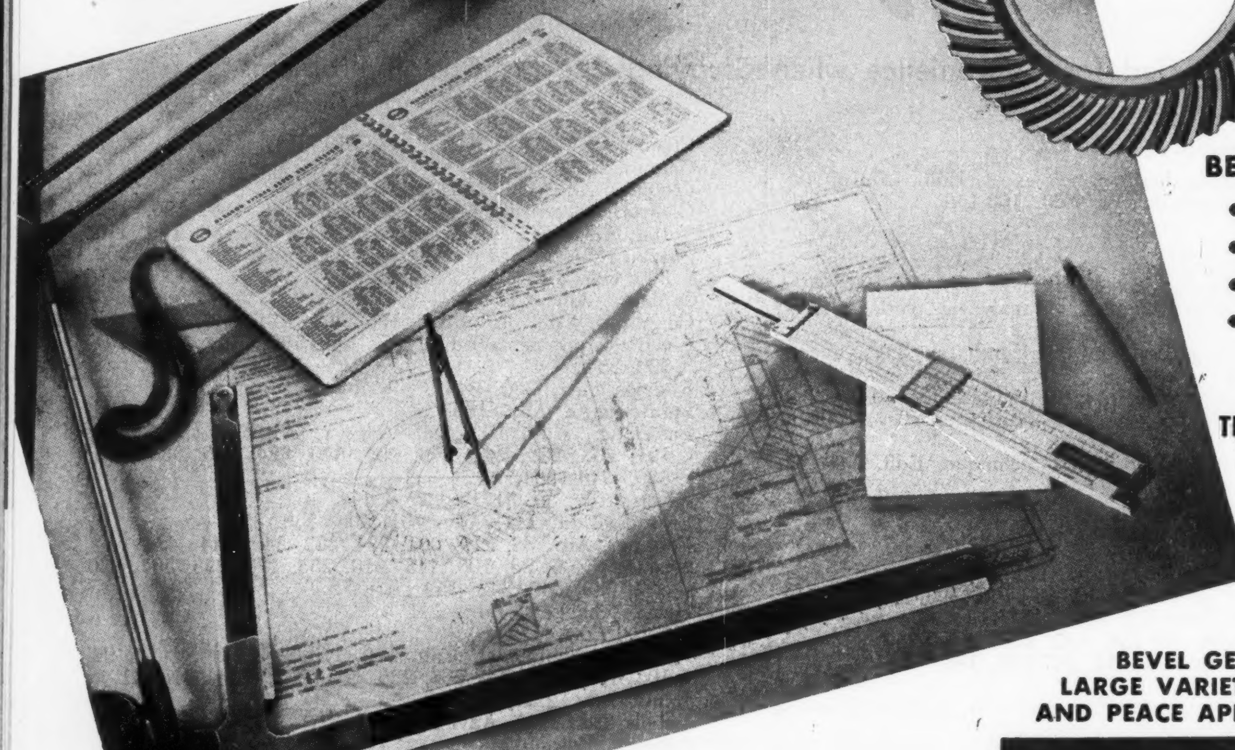
Itemized Index

Classified for Convenience when Studying Specific Design Problems

MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally.

GLEASON ENGINEERING SERVICE . . . FOR DESIGNERS OF GEAR DRIVES

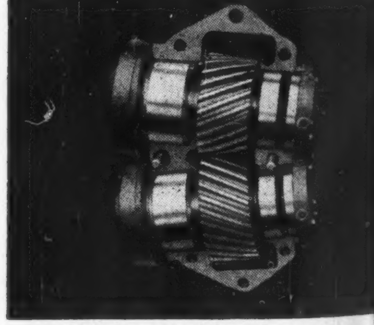




BEVEL GEARS
- **Straight**
- **Spiral**
- **Zerol**
- **Hypoid**

for POWER TRANSMISSION AT ANY ANGLE

BEVEL GEARS FOR A LARGE VARIETY OF WAR AND PEACE APPLICATIONS



Angular spiral bevel gears . . . for PT boat V-drives

Large spiral bevel gears . . . for continuous rod mill drives

Do your bevel gear designs meet these 3 tests?

1. Are the gears of the type, material, size and pitch best suited to the requirements of the drive?
2. Is the design of the gears such that they can be easily manufactured?
3. Are the mountings designed to maintain the alignment and position of the gears under operating loads and speeds?

Before your designs are frozen, send your preliminary layouts to the Gleason Works. Our 75 years experience in making power "turn a corner" is at your service. We will be glad to check your gears by these 3 tests, offer recommendations for improving the drive and prescribe machines for manufacturing the gears. When writing, please include data on the horsepower and speed required, the type of loading (constant, intermittent or shock) and the driving member and direction of rotation.

GLEASON

GLEASON WORKS

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ARMY E NAVY

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The former batch heating method—hot, dirty, cumbersome and non-uniform—required 2½ hours to heat the hubs. Total output averaged 45 per hour.

The 5-station TOCCO Induction Heating machine shown above—compact, clean, cool and accurate—heats 9″ of the 5¼″ diameter hubs to 800-850° F. uniformly throughout both length and cross-section. Every 47½ seconds, a prop is ready for the upsetter which is shown at the left of the TOCCO machine. Output of this one TOCCO unit averages 70 per hour . . . 55% faster than former method.

Find out how TOCCO can speed up your war production . . . improve your products and working conditions . . . cut your postwar costs. Write for free copy of "Results with TOCCO".

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TOCCO

INDUCTION

HARDENING . . BRAZING

ANNEALING . . HEATING

Topics

EQUIPMENT REQUIRED for transmission of television is equivalent to that needed for 960 simultaneous telephone messages, because of the number and range of impulses necessary for pictorial transmission. Also, in order for the pictures to be received in focus it is necessary that the various impulses arrive in phase within .000001-second.

SYNTHETIC LATEX COATING of metal parts gives protection against acid and alkali corrosion. It also provides abrasion resistance as well as a cushioned and nonslip surface. Several types of synthetics have been employed satisfactorily, including neoprene and buna S. In addition to its other properties this coating, developed by U. S. Rubber, has been invaluable where the possibility of static or spark would cause explosion, fire or shock.

ELECTRIC MOTORS immersed in aircraft fuel tanks have utilized Pliobond, an organic cement, effectively as a seal to prevent gasoline or other fluids from seeping inside, according to Goodyear Tire & Rubber Co.

NEW GLASS which is resistant to corrosive effects of hydrofluoric acid has been developed by the American Optical Co. In a test no obvious attack was perceptible after 500 hours, whereas ordinary glass would be disintegrated within a few hours. Instead of sand the major ingredient is phosphorus pentoxide. Working properties of the glass are about the same as ordinary glass, requiring no special equipment or technique.

PHOSPHOR DUSTS for coating fluorescent-light tubes are deposited electrostatically instead of being flowed-on in a solvent as formerly. In the new method an ionizing wire is placed in the tube, creating a high potential between wire and tube. Phosphor dust is blown through the ionized tube. The particles are ionized positively and are deposited permanently in an even film on the glass tube. Deposited dust gives up its charge and becomes an insulator, leaving only uncoated glass to attract the particles.

MAGNESIUM ALLOYS have been utilized increasingly during the war to the extent that the average fighting plane employs approximately half a ton. It now appears possible that all-magnesium structures may be used. According to J. C. Mathes of the Dow Chemical Co., success of wings fabricated entirely of magnesium on the Navy's SNJ-2 advanced trainer "foreshadows all-magnesium airplanes in the very near future."

BLACKING OUT of pilots resulting from maneuvers which cause the blood to leave the brain has been greatly minimized by the Franks flying suit, a development of the Canadian Air Force. A skin-tight garment, with a rubber skeleton lining covering the body from ankles to chest, is pumped full of water. When gravity pulls at the pilot a corresponding balancing force is created in the suit to facilitate the normal flow of blood to the brain instead of pooling it in the pilot's feet.

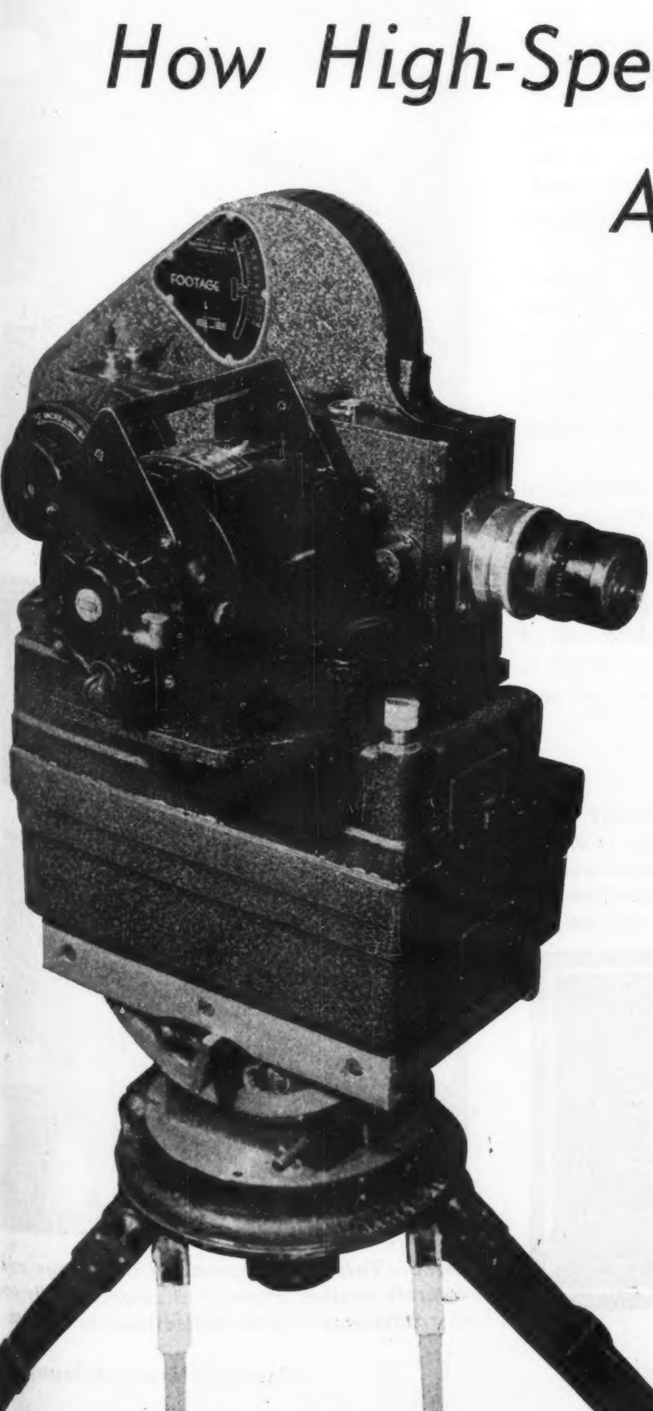
IN CIVIL AIR CARRIERS, no personnel injuries resulted from engine failure during the two and one half years from January 1941 to June 1943, involving 340 million miles of travel. During this period, engine failure caused seven forced landings in which three planes were damaged. Since 1937, engine structural failures have numbered only 2.5 per million miles flown, while total engine failures from all causes reached about 7.4.

OPINION HAS BEEN that jet-propelled planes are equal in efficiency, at say, 300 miles per hour to other types of combat planes, as reported in "Topics" recently. This, however, is incorrect as jet propulsion is highly inefficient except at much higher speeds where it is likely to come into its own.

How High-Speed Photography Aids in Redesign

By W. S. Calvert
High-Speed Motion Picture Consultant

and H. D. Jackes
Wright Aeronautical Corp.



AS LONG as there are high-speed mechanisms there will exist a need for methods of motion analysis. In slow-speed machinery the motion usually can be depended upon to be as designed, but as speeds increase deflections and impacts cause motions not intended in the original design, these often leading to improper functioning or premature failure.

The importance of being able to measure motion is indicated by the number of methods developed for this purpose. They are all useful and all have their strong points and weaknesses. One of the best-known methods is visual observation, utilizing a flashing light or a rotating shutter. This stroboscopic analysis is usually the first method employed in motion analysis. It is easy to apply but is limited to parts subject to recurrent motion, giving an aver-

Fig. 1—This high-speed camera, of the rotating prism type, has a built-in automatic timing clock

age picture of what has transpired during a great number of cycles. Intermittent malfunctioning of a mechanism may be unnoticed and conditions of severe personal discomfort may limit seriously the quality of the observation. There is no record other than that impressed on the memory of the observers which is a handicap when an accurate comparison is desired.

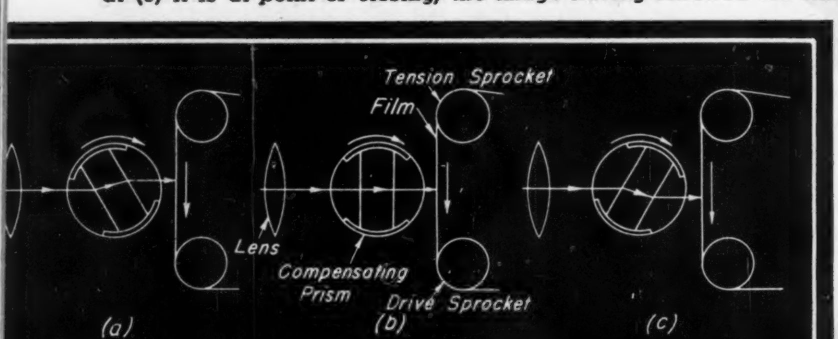
Seismic recorders, both mechanical and electrical, are excellent for special applications such as determining the torsional vibration in a rotating shaft or the vibration of a platform, but are restricted in application to systems that can tolerate a considerable mass without affecting the motion, and are limited to measurement of fluctuations of uniform motion. The records being wavy lines on a sheet of paper require specialized training to interpret with any degree of certainty.

Electrical strain gages, consisting principally of conductors which have resistance characteristics that vary with strain, together with suitable electrical indicating and recording equipment, are widely used to determine stress and vibration in engine parts, propeller blades, bridge members, etc., during operation. The principal limitation of strain gages is that they are "local," that is, they record what is occurring between their points of attachment to the structure under question. They may be applied, however, in any number desired. The only limitation in this respect is that of complexity. Strain gages have a finite mass and cannot be applied to extremely light members such as small springs, reeds, threads, etc. A further difficulty is that of making electrical connection to the recording equipment from a high-speed rotating or oscillating member. Again the records are wavy lines on a sheet of paper.

There are many other types of motion indicators, some depending on measurements of the reluctance of a magnetic circuit, others on visual principles, such as lining up two peepholes by means of a micrometer screw, one being attached to the reciprocating part being investigated and the other to the micrometer. These all have special applications in which they are excellent but they usually are limited in scope.

The high-speed motion-picture camera is an important addition to the devices designed to analyze motion. High-speed photography involves taking a series of pictures on motion-picture film at extremely high speed and projecting them at a much lower rate. Cameras are commercially available which are capable of exposing 8000 frames per second. These, when projected at the standard rate of 16 frames per second, give an apparent time magnification of 500:1. Reasonably satisfactory projection is obtained at 12 frames per second with resulting increase in time magnification to 667:1.

Fig. 2—Schematic diagram of a rotating-prism, optically compensated, high-speed camera. Action of rotating prism is shown causing image to follow constant-travel rate of film during exposure. At (a) barrel shutter has just opened, at (b) it is in midposition and at (c) it is at point of closing, the image having followed the film



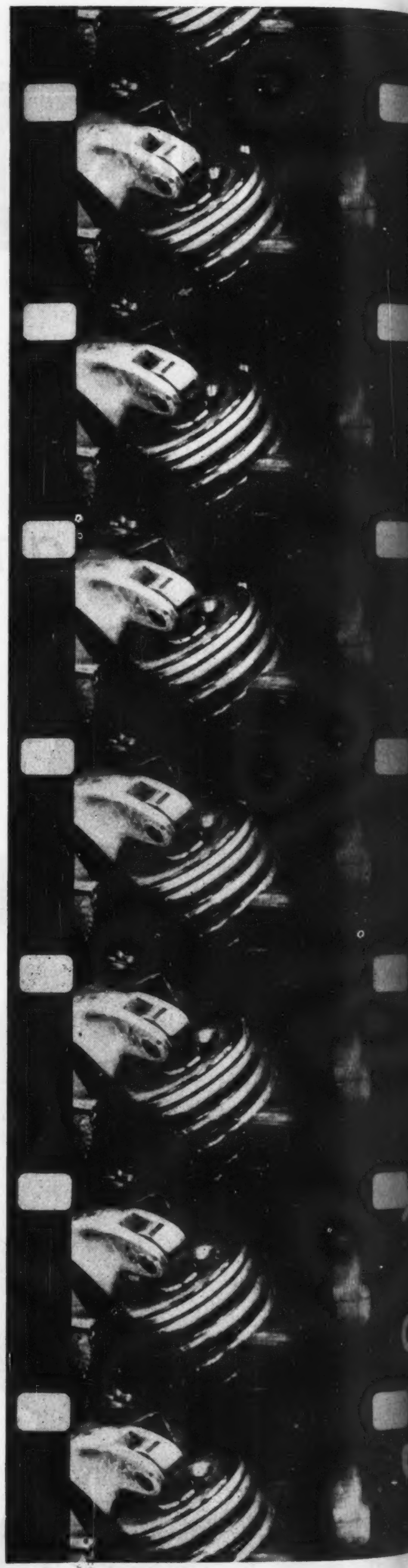


Fig. 3—Valve gear operation in a large radi aircraft engine. Pictures disclosed faulty op ation was due to deflections in system

Fig. 4— in mot operati

Fig. 4—*Action of valve tappet rollers and cam in motion assisted in the analysis of valve operation. Camera could see through oil haze*

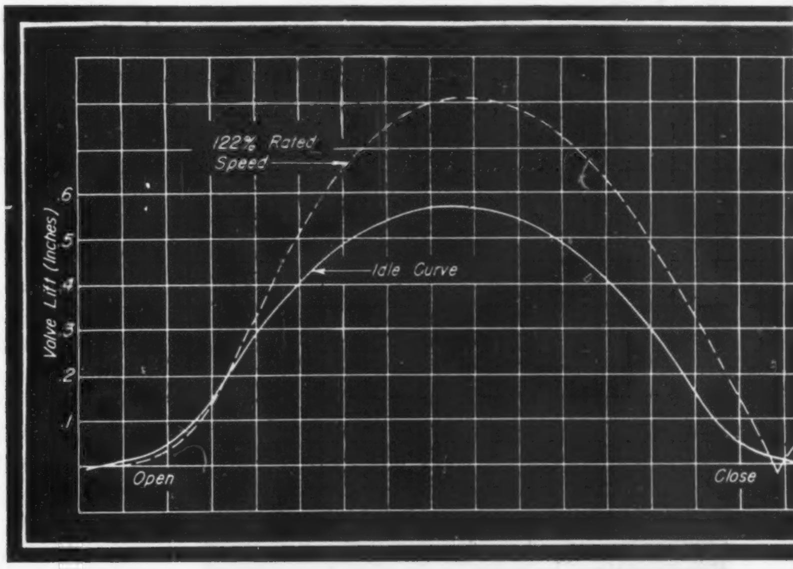
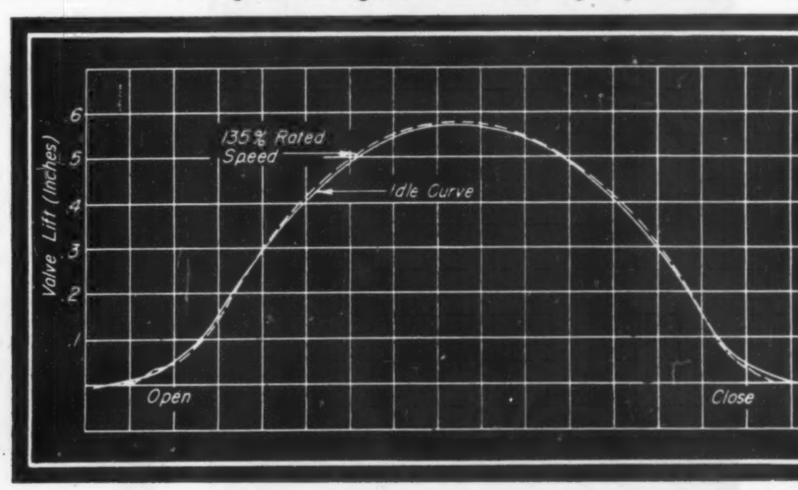


Fig. 5—Above—Valve gear operation for Fig. 3 before redesign, showing spread between idle and high-speed operation

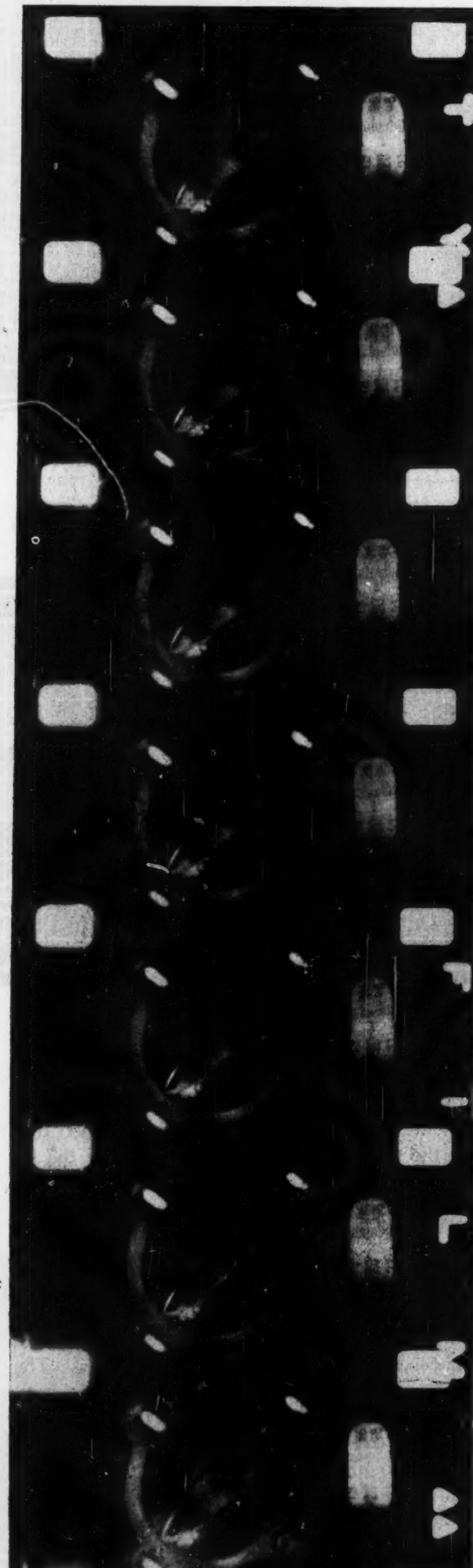
Fig. 6—Below—Improved operation over speed range is obtained from valve gear redesigned to increase rigidity



In the conventional motion-picture camera the film is exposed by opening and closing the shutter, advancing the film one frame, exposing again, and repeating. The top limit in this type of camera is determined by the rate at which the film can be stopped and started, depending on the strength of the film itself. Since the inertia forces are proportional to the square of the speed, it is apparent that there is a definite limit to the speed of operation which refinement in design, added sprocket holes, etc., can do little to change.

Several types of high-speed motion picture cameras are in use. All work on the principle of moving the film strip past the lens at a high speed with no intermittent motion. One type utilizes a 35mm film driven at a high speed past a lens which has no shutter. The film is exposed by the flashing of an intense stroboscopic light, synchronized with the speed of the film with the result that the exposure coincides with the proper frame divisions in the film. It is understood that with this type of equipment exposures up to 1500 frames per second are possible. Excellent results are obtained upon enlargement, giving undoubtedly the most satisfactory method for extremely short exposures, on the order of 1/100,000-second, with a minimum of blurring. The principal disadvantages are the bulki-

Fig. 7—Study to determine if seating action of exhaust valve was correct. Camera was in the direct blast of the exhaust gasses



ness of the associated equipment and the need for darkening the surroundings in order that the only exposures will be those due to the stroboscopic light.

Another way to obtain a proper exposure on a continuously moving film strip is to compensate for the motion of the film in the optical system. There are two methods for doing this. One is to match several lenses and mount them in a rotating member in such a manner that the motion of the lens is synchronized with that of the film with the result that the image travels with the film for a finite distance, giving an exposure that is not blurred by the motion of the film. It is apparent that the difficulty and expense of matching and mounting the lenses is the principal fault with this system, making the cost of such a camera prohibitive for the average user. The second method utilizes a stationary lens and a compensating prism between the lens and the film. The prism is driven to move the image at the same speed as the film during the exposure period. Such a camera is shown in *Fig.* 1.

It should be noted that the rotating prism will introduce aberrations, with some slight loss in sharpness of detail. The exposure is roughly one-third of the total frame-cycle time, there being some variation between the different designs of this type camera. This results in a shutter opening of about 1/20,000-second for a 6000 frame per second camera (for comparison) compared to 1/100,000-second exposure for the flashing light camera at 1500 frames per

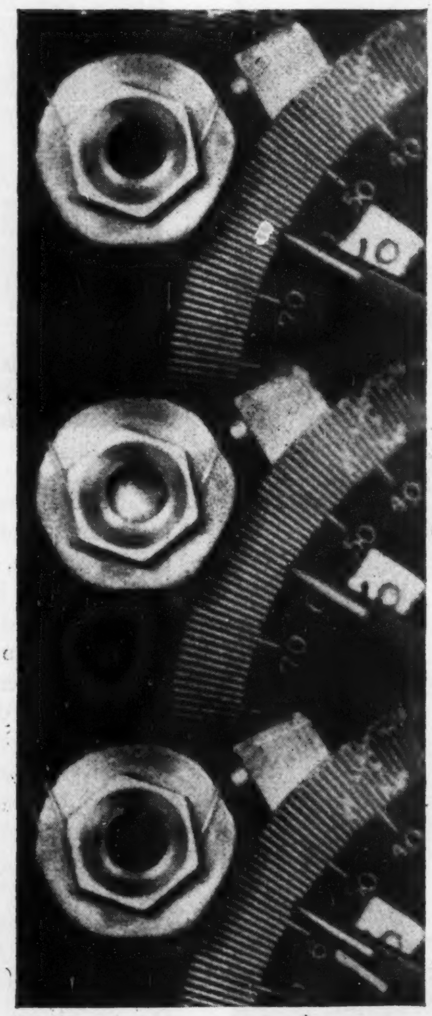


Fig. 8—Spark timing check indicates precise time of firing as in the middle exposure. Timing was within one degree over entire speed range

second, or an exposure duration ratio of 5 to 1. The flashing light camera, therefore, with its shorter exposure will "stop" motion which is beyond the range of an optically compensated camera but is penalized due to its lower taking rate. A schematic diagram of the continuous strip rotating-prism high-speed camera is shown in *Fig.* 2. In the type of camera shown the compensating prism rotates one-half turn per frame which results in a rotational speed of 75,000 revolutions per minute at a camera speed of 2500 frames per second.

As continuous-strip high-speed cameras subject the film to high accelerations and high velocities (on the order of 100 feet per second), one of the limitations is the strength of the film itself. To obviate this, one type of camera has the film wrapped on a large drum which is first brought up to speed, then the shutter is opened to expose the film for one revolution of the drum. This is used with the rotating lens type of optical compensation with the result that pictures may be taken at a rate unequalled by any other camera.

Because it often is desirable to make a frame-by-frame inspection of the high-speed film, an exact knowledge of the taking rate is essential to an accurate study of the subject. For such cases it has been found desirable to include a timing device in the field of view. Some cameras have a built-in timing clock which is projected on the film simultaneously with the subject. Most of the examples

Fig. 9—Below—Because motion-picture study in Fig. 10 was not sufficiently clear, this single-flash picture was taken to disclose the action of the entrained air

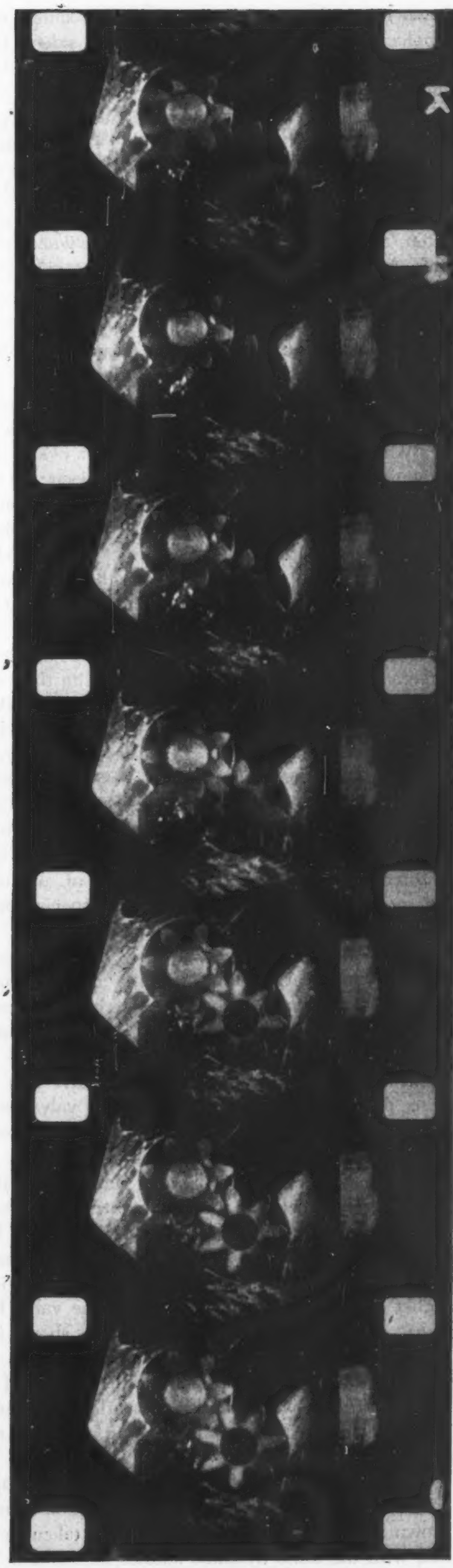


Fig. 10—Action of oil flow through transparent pump showing effect of entrained air

shown herewith were taken with such a camera in which the clock dial is shown on the right-hand side of the films. The scale divisions show the time to the closest .002 of a second.

Where a clock is not provided in the camera, reliable timing can be obtained by including in the field an arc light or one of the fluorescent lights operated on alternating current. This will give an exact measure of the taking rate as indicated by the number of frames for each flash. Often, a part of the subject is a dial or wheel which rotates at a known rate. This also will provide a satisfactory measurement of taking rate.

Measurements Are Taken from Projection

The most satisfactory method of frame-by-frame inspection the authors have found is to project the film in a device which enlarges 16mm film to about 6½ by 9 inches or 8mm film to about 3 by 4½ and projects the enlarged image on a ground glass window. Direct measurements may be taken as desired and suitable graphs or charts prepared. Photographic enlargements of high-speed motion pictures have not been too satisfactory compared to a projected image of the original film, at the same magnification as the photographic enlargement.

Many investigators have utilized the motion-picture camera in one form or another to expedite their research. Applications of high-speed photography to motion analysis in aircraft engines will be discussed in the following to illustrate typical studies. Analyses of the photographs indicated where corrections and redesign were necessary. The film strips shown were taken with a rotating-prism optically compensated high-speed motion picture camera, *Fig.* 1. Because of its compactness, ease of handling, sturdiness and ability to take pictures of any object on the spot without the need of further special provisions, this type of camera was chosen for the work.

Shown in *Fig.* 3 is a high-speed study of valve-gear operation in a large radial aircraft engine. Analysis of the motion, through both picture projections and time-motion studies, *Fig.* 5, yielded valuable information concerning valve dynamics and causes of failure at high speeds. Previous conceptions of the valve-gear problem were principally concerned with the valve-spring frequency and surge conditions, as surge was most readily seen by stroboscopic methods.

Valve springs of considerably higher vibration frequency and higher load values were tried, resulting in an appreciable reduction of the surge condition but with rather indifferent success with respect to increasing the valve jumping speed and correcting malfunctioning at higher speeds. The opening side of the valve lift curve in *Fig.* 5, prepared from the photographs shown in *Fig.* 3, indicated that there was excessive deflection in the linkage. Various redesigns to increase the rigidity of the linkage were tested, with the result that the valve motion was improved to the degree shown in *Fig.* 6 with a minimum of changes to the engine.

In *Fig.* 4 is a series of pictures of the valve-tappet roller and cam action associated with the valve and rocker arm shown in *Fig.* 3. These pictures were taken in conjunction with the same dynamic studies mentioned. Purpose of the analysis was to detect any wobble of the valve-tappet rollers in following the cam. Also, it was desired to disclose any skidding between the roller and cam, with respect to roller and cam scuffing. The results indicated satisfactory operation and analysis of these films aided considerably in the valve motion analysis.

Pictures of the exhaust valve action in *Fig.* 7 were taken through the exhaust port with the engine operating at full power, the camera being in the direct blast of the exhaust gasses. The flame did not have sufficient luminosity to register except at the corner of the port at valve opening. These pictures were taken for two reasons: To measure the valve seating velocity and impact and to see if the valve seated squarely or on one side and then slid over. The pictures indicated that the seating velocities were as calculated and that the valve did seat properly.

Spark timing check of a special magneto for a high-speed engine is indicated in *Fig.* 8. The spark is fired in a "bomb" at 200 pounds per square inch pressure to simulate compression pressures encountered in high-compression engines. The spark is recorded simultaneously with a positively driven pointer and dial, giving an exact measurement of the instant of spark occurrence.

Photographs Absolved Magneto of Blame

Because of the voltage buildup prior to the spark discharge, due to the secondary circuit in this magneto, timing devices such as a neon bulb fired by a trigger circuit would give false readings, often indicating spark firing in advance of the actual spark. The timing thus indicated would vary up to 20 degrees at maximum speed. The check taken with the high-speed camera indicated the true spark to be within ± 1 degree over the entire speed range. This finding saved much unnecessary changing of magnetos when investigating engine difficulties and absolved the magnetos of much blame.

To indicate the effect of entrained air in the inlet oil in a pump the pictures in *Fig.* 10 were made. As had been expected, the majority of the air recirculates, seriously interfering with performance. In this case the definition given by the high-speed camera was not sufficient for all phases of the study. Consequently, a flash picture, obtained by a single flash from a Strobolux, was made as shown in *Fig.* 9. This has excellent definition and shows the dark area on the outlet side of the pump where the pressure has increased to compress the air bubbles until they are no longer visible. The pressure is shown all the way around the pump gears to the inlet passage where it is held by the last tooth.

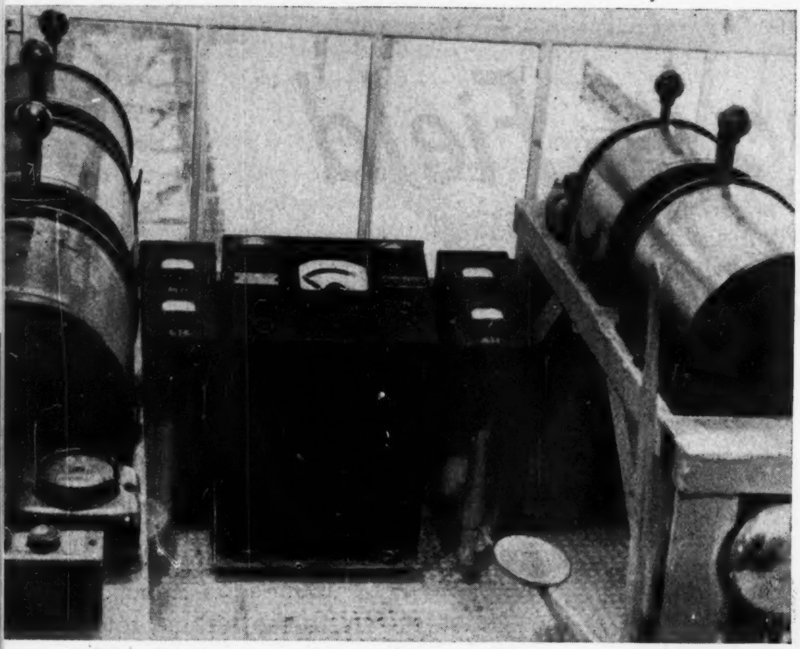
These studies are indicative of the motion analyses possible with high-speed photography. There are many design problems where dynamics become so involved that it is necessary to study actual operations in this way to ascertain how they agree with calculated performance.

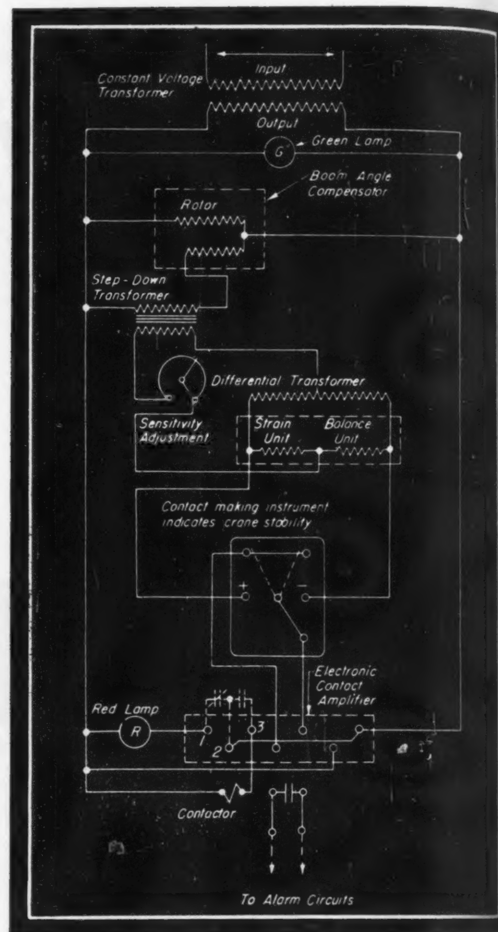
Increased Production Efficiency along with definite decrease in accidents and absenteeism have been obtained through a new color scheme adopted by Consolidated Vultee Aircraft Corp. Psychological application of colors to machine parts is based on the use of colors with wave lengths which quickly attract the worker's eye to the critical or operating parts of machines. Other areas employ colors that are restful to the eyes but not of a fatiguing contrast.

Scanning the Field for Ideas

Increased efficiency over a wide range of speeds has been obtained for steam turbines through the development of blunt-edge reaction blades as shown on the turbine rotor at left. Indicative of the evolution which has taken place in blades, a previous design is being held alongside the rotor for comparison. The new blade, designed by Westinghouse, looks in cross section like an airplane wing with its blunt leading edge. In addition to operational advantages for marine and industrial service where variable-speed turbines are used, several constructional advantages have been achieved. Because the blade is of heavier section more area is available for shroud fastening, making possible the use of rivets instead of welding. This is preferable for shroud fastenings because of fewer heat-imposed stresses. Also, the thicker blade has a higher natural period of vibration and is stronger than previous designs. Rows of blades may be spaced more closely in a given shaft length, giving a more compact turbine for the same rating.

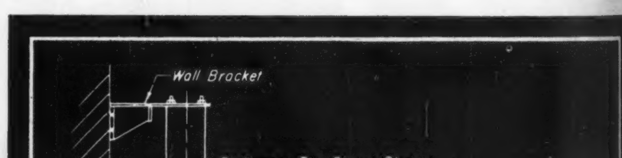
Stability gage to safeguard equipment where operating conditions may produce unstable loading has been developed to permit maximum use of equipment and eliminate loading errors due to operator judgment. Mounted in the stand of a crane, gage controls are shown at top of next page. The gage is in the center and load-indicating ammeters are mounted on each side. A simplified circuit diagram for the gage, developed by General Elec-





tric company is shown in the illustration at right.

In principle the gage measures the tipping moment or the degree of stability by determining the amount of deformation in the structural member upon which a strain gage is mounted. Any deformation in the member changes a small air gap in the strain gage and, since this gage and its balancing unit form two legs of an alternating-current bridge, the change causes a deflection to register on the indicating instrument. The indicating unit contains a partial bridge circuit, transformers, a sensitivity adjustment and an electronic relay for operating the control circuits. For compensating the gage circuit output for various angles of the boom, a compensator consisting of a rotary voltage regulator is incorporated in the circuit.



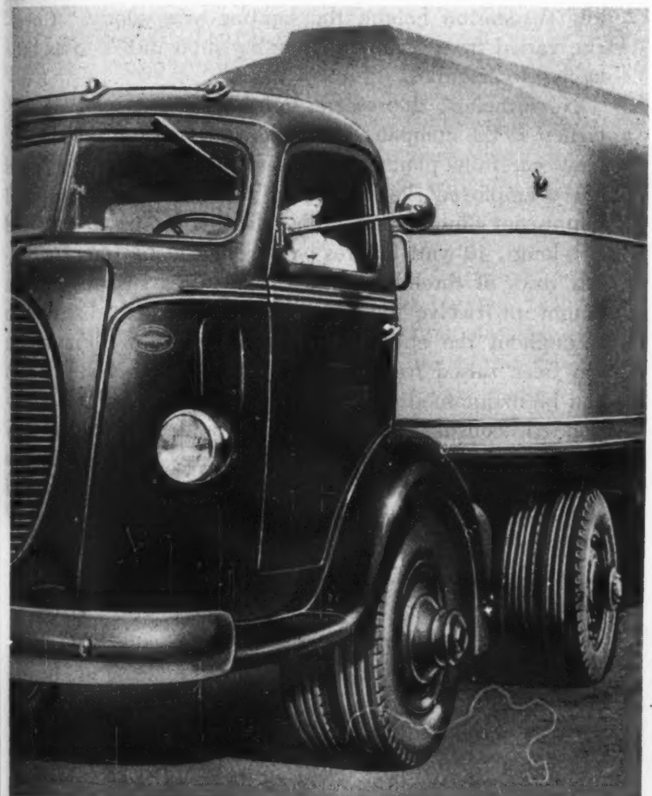
Stepped shaft which serves as a stationary "plunger," as shown right, simplifies design and construction features of a jib crane and utilizes only two external seals, one on each end of the casing. When hydraulic pressure is applied to the system, the casing and boom "climb up" the plunger. The lifting force is dependent upon the difference in area between the two portions of the plunger. In this design no piston rings are required to provide a seal.

The plunger length is twice the amount of travel plus the width of the bearings, packing, brake and clearance. Casing length in this design is the travel plus 13 inches. This gives a liberal vertical spread between the babbit-lined support bearings, reducing the bearing loads and consequently the friction loss during either vertical movement or rotation. Rotation of the crane is relatively easy with full load due not only to the low bearing loads but also to the fact that the

vertical load is supported on a column of oil under pressure, forming a hydraulic thrust bearing. This unusual design was developed by the Rotary Lift Co.

Operation may be by air pressure as a self-contained unit in which the plunger itself is the air-oil reservoir. Control is either by air valve only or by use of both an air and oil valve. By using the oil valve an oil-locked hydraulic system is obtained which gives greater accuracy of control and eliminates the spongy or floating action.

Increased loading on front-wheel axles of trucks and other automotive equipment makes possible bigger payloads and more economical operation of equipment. This added capacity is achieved through utilizing independently mounted dual wheels on the front axle as shown in the photograph at left. Designed by Differential Wheel Corp. these dual wheels are mounted behind the conventional position, as shown, allowing the engine weight to overhang. This increases the proportionate weight carried by the front wheels and allows the rear wheels to carry more freight. Increased safety is also obtained through the use of two independent tires on each front wheel.



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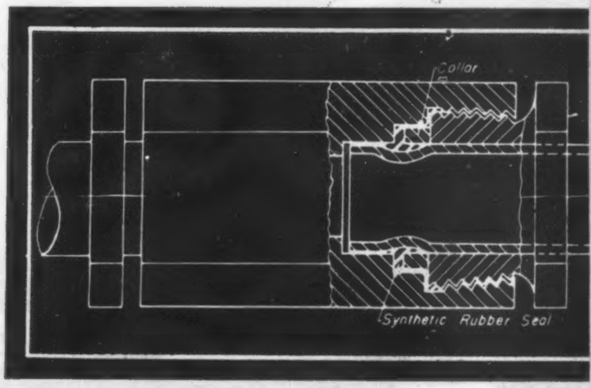
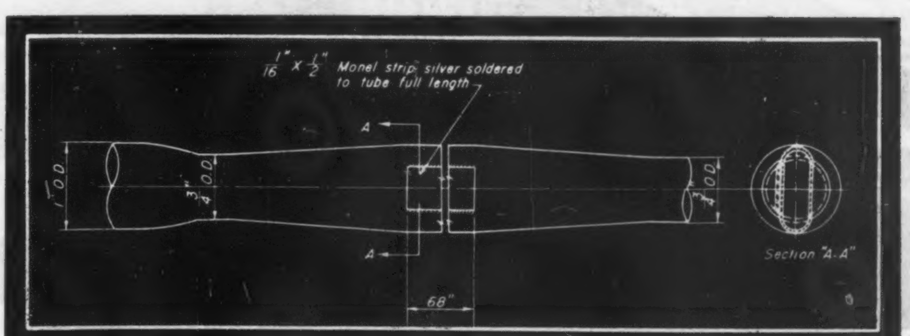
Synthetic rubber seal provides a simple compression joint in the hydraulic tube fitting shown below. Developed by the Glenn L. Martin Co., the fitting obviates flaring operations and provides a joint with greater resistance to vibration breakage than do flared types. The synthetic ring placed over the tubing is compressed in the fitting body by the nut to the point where the tubing is actually beaded by the ring and the rubber is forced into every crevice to form an effective joint. A metal collar is interposed between the ring and nut so that the nut does not come in contact with the ring and tear it. Pull-out strength of the joint, naturally, is limited by the sheer strength of the rubber.



Self-cleaning heat exchanger tubes utilize strips of monel to produce thermal shocking. When steam or hot gasses are passed through the tubes, causing evaporation of the liquid on the outside, the flexing or bending of the tubes under temperature changes breaks off any brittle or hard scale which forms due to the depositing of minerals and solids during the evaporation process. Designed by Heat Transfer Products Inc., the 6½-foot tube shown in the drawing at right has a 68-inch strip of 1/16 by ½-inch monel soldered full length to the tube.



Improved Lighting—Better Work

By George J. Taylor
General Electric Co.

BECAUSE no man can work more accurately than he can see and because engineers and draftsmen need all the seeing aids that can be given them, office lighting of higher intensities and better distribution than was considered adequate in the past pays ample dividends. Longer hours of detail work during wartime often imposes fatiguing strains on eyes to the point where errors readily creep in.

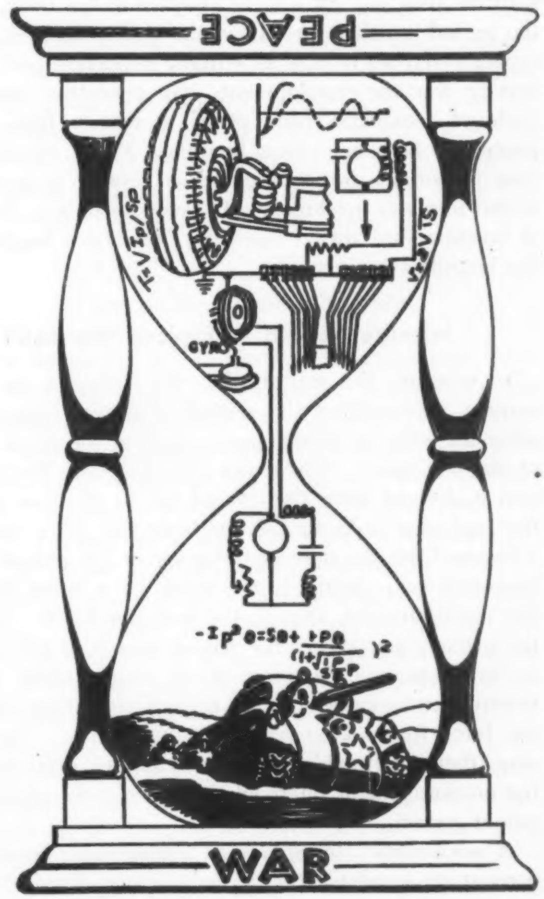
Realizing that accurate workmanship cannot be expected under unfavorable conditions, Gould and Eberhardt Inc.—whose engineering department is illustrated below—has applied the latest engineering principles to the lighting of their offices and plant. When good incandescent industrial fixtures were first developed this company provided workers with the five footcandles of illumination that then constituted the best available lighting practice. Later, when fluorescent lighting came on the market, a test installation was put in. The new light source was applied in the general office as well as in the engineering department, an area of about 8000 square feet.

Although this installation raised the average illumination from five to twenty footcandles, company executives were not satisfied. Fixtures had been suspended at a height of 6½ feet. The rooms, being relatively large, made the fixture hangers plainly visible, adding to eye strain. Also, because of the size of the rooms and the low suspension height, the lighting was spotty. Coverage varied from as much as eighty footcandles to as little as five footcandles.

Nevertheless, fluorescent lighting had proved its efficiency so the company set out to improve the installation. New carefully planned and designed lighting now gives every employee the same high levels of well-distributed fluorescent illumination. The old four-lamp, 20-watt and two-lamp, 40-watt fixtures were replaced by four continuous rows of three-lamp, 40-watt fixtures suspended at a height of twelve feet to assure equalized distribution throughout the entire office area. Over-all illumination has been raised from twenty footcandles to levels which can be maintained at well above fifty footcandles. A suspended acoustical ceiling has been added which not only increases the utility of the new fixtures but also adds to the efficiency of the office by introducing the element of noise control.

AN ENGINEER in Pittsburgh deserves primary credit for the winning of the battle of El Alamein. How could this be, when he was more than 5000 miles from the actual fighting? The answer is, invention—an extremely ingenious piece of mechanism which enabled Montgomery's tanks to score hits while roaring full speed over rough ground. The battle was one primarily involving tanks where mobility and accurate fire power were paramount. Prior to this invention tanks were required to come practically to a stand-still when shooting, in order to keep their aim on enemy tanks. Jarring or pitching of the tank while rolling over rough ground would cause the gunner to miss.

Fig. 1—Peacetime inventions such as the shock absorber, gyro and voltage control emerge as vital weapons of war such as the tank-gun stabilizer



It was accurate shooting on the run which turned the tide against Rommel. Even with the enemy deep in Egypt and with no signs of retreating, Montgomery no doubt had foremost in his mind the tremendous advantage which the gyroscopic stabilizer—the invention mentioned—gave his tanks over the outmoded Nazi tanks, when he kept predicting quietly to Wendell Willkie, "Egypt has been saved!"

A combination of several peacetime inventions which had their beginning at least ten years before the battle comprised this invention. As early as 1930 the Westinghouse engineer who developed the stabilizer made a series of inventions upon shock absorbers for automobiles, and first learned to analyze the requirements for smooth riding comfort in cars. This was followed by a series of others, involving gyroscopic regulators and delicate electrical controls, principal of which was the well-known Westinghouse Silverstat, a device for regulating voltage. Without the accumulation of knowledge and experience furnished by these developments, it would have been almost impossible for a man to have made this outstanding invention, which has saved thousands of lives among our fighting forces.

Group Invention Must Be Upheld!

By George V. Woodling

The foregoing example is just one instance of how wartime inventions have had their basic conception during periods of peace. While it constitutes a major achievement during this war, there are legions of other inventors and engineers doing equally effective work. For instance, the growth of radio since 1918—the end of the last war—and the accompanying study of the behavior of high-frequency currents and electrical waves led to the development of radar equipment, which saved England from destruction by the Nazi bombers.

In addition to these more spectacular electrical and mechanical inventions, the greatest chemical and metallurgical minds of the country have made noteworthy achievements which are aiding the war program. The shortage of steel has been met by producing high-grade iron castings by a scientific method of control in the

foundry. Crankshafts, camshafts, gears and other critical parts of machinery made of cast iron now replace steel forgings.

When the history of the war is written, the achievements of engineers in adapting peacetime inventions to wartime uses will fill a large chapter of the book, and in the period which is to follow, the public will confidently expect inventors to play an equally important part in converting wartime developments into peacetime use. The cycle of conversion from peace to war or from war to peace may be likened to an hourglass, *Fig.* 1, where peacetime inventions are represented as flowing or being converted into war machinery. In peace as in war, the sands of invention are always flowing. Conversion begins when the hourglass is reversed.

Incentive Needed To Replace War Spirit

In wartime, the war itself is the incentive for the inventor. Throughout the period of peace, however, another incentive to invent must supplant the driving force of the war spirit. Under our patent system this stimulation is derived from the reward which gives an inventor the exclusive right to use his invention for a period of 17 years from the date of the grant of the patent. If the seventeen-year period is cut short by a court declaring the patent invalid, *Fig.* 2, the inventor loses. Although the primary purpose of the patent laws is to aid the public by promoting the progress of science rather than to reward the inventor, yet the reward constitutes the driving force for making peacetime inventions. The surest way, then, to provide in peace what we need in war is the encouragement offered by an efficiently administered patent system.

A wholesome atmosphere of encouraging inventors to convert or combine the basic wartime discoveries into postwar equipment will hasten our general effort to create jobs for returning soldiers. Immediately following the last war there was a rapid rise in the number of applications filed in the Patent Office, *Fig.* 3, and it is expected that the growth of inventions in the impending postwar era will be correspondingly great and probably will follow the patterns charted after the last war. It is to be noted that during both wars the number of applications sharply dropped.

Trend Is To Declare Patents Invalid

Stimulation for creating new things has been stressed here because in recent years there has been and still is a so-called "doctrinal trend" in some court decisions to declare patents invalid and cut the seventeen-year period short. Although this trend is hostile to patents, it is not to be assumed that all courts are hostile. The many conflicts of decision leave the inventor to take the consequences. The importance of eliminating this confusion and thereby giving encouragement to inventors constitutes a paramount problem in correcting our patent system in order to make it work efficiently for war and peace. The effect of this doctrinal trend is to destroy the force that drives engineers to invent, and is aimed mostly at private research laboratories. If not stopped, it will take

Fig. 2—When patent is declared invalid, inventor loses part of the seventeen-year privilege which is his reward

away from the American people the benefit of much research and invention.

The ingenious manner in which the new trend operates in patent decisions involves setting up a test for invention which excludes the patenting of many things, even though the inventions may constitute an exceptional or surprising engineering achievement. For example the Supreme Court, applying this new test, held invalid the broad claims of the Marconi patent for wireless telegraphy*. Thus, forty years after the invention the court's decision reduced an inventive creation to an electrical mechanic's application of mere skill in the art.

The new test ignores whether or not the invention constitutes a major engineering accomplishment, but attempts to decide the question of patentability on the basis of the individual achievement of the inventor. The test becomes: Did the inventor's mind experience a "flash of genius?" Did his imagination suddenly leap to great heights to reach the invention? If it did, then that which he produced under the new doctrinal test of invention is considered to be patentable, regardless of the thing created or the actual contribution made in advancing the progress of science. The following language taken from a recent decision illustrates the philosophy back of the new trend:

> "Patents are not intended as a reward for a highly skilled scientist who completes the final step in a technique, standing on the shoulders of others who have

*Patent No. 1 763 772. Application was filed Nov. 10, 1900 and the patent was granted June 28, 1904. Suit for infringement was filed on July 29, 1916, and the case was in the courts from then until finally decided by the Supreme Court June 21, 1943.

gone before him. By the same token they are not intended as a reward for the collective achievement of a corporate research organization. Today routine experimentation in the great corporate laboratories can produce results beyond the imagination of twenty years ago. But such contributions to industrial art are more often than not the step-by-step progress of an entire group, not the achievement of an individual. Such an advance is the product not of inventive ability but of the financial resources and organizing ability of those who operate the laboratories.

"To give patents for such routine experimentation on a vast scale is to use the patent law to reward capital investment, and create monopolies for corporate organizers instead of men of inventive genius.

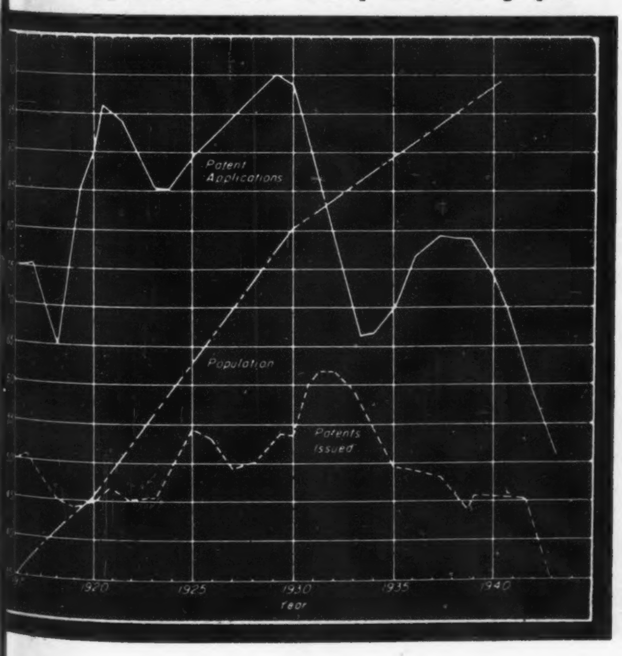
"The corporate research laboratory of today has given us the greatest invention of modern times, the knowledge of how to invent. Under a disorganized system of invention a hundred men would hunt for the needle in the haystack, the prize going to the successful finder while the efforts of the others served only to scatter the hay in all directions. Organized invention has changed the entire process. Each man is given a section of the hay to search. The man who finds the needle shows no more "genius" and no more ability than the others who are searching different portions of the haystack.

"We are bound to interpret the patent law in the light of its purpose declared by the Supreme Court, to reward individual and not group achievement."

Trend Encourages Belittling of Associates

Under the impact of the foregoing decision and others of a like nature, the inventor working for a large research laboratory has the burden of showing that he did not stand on the shoulders of others at the time of conceiving or grasping the invention. He must show not only that he suddenly leaped to a great height to reach the invention

Fig. 3—Below—Although population has increased steadily since the first world war, patents applied for and granted have, on the whole, diminished in number. Effects of wars and depressions show clearly on these graphs



but that his associates gave him no boost in making the inventive jump. Should the new doctrinal trend receive sufficient momentum, the belittling of one's associates would be the order of the day. The natural effect would be to cause group achievement to break up and force individual inventors to become secretive about the things on which they are working so that others cannot possibly claim to have had any hand in making the invention. Under the prolonged influence of the decisions charting the new trend, the kind of cooperation which is now winning the war will cease when victory is won. When decisions create such an unhealthy atmosphere, then it is time for a return to sound thinking.

Group Action Hastens Progress

Group achievement can develop new products in a much shorter time than individual achievement, as has been amply demonstrated during the war. When robot bombs began to destroy a city we could not wait upon individual achievement to save the day—the situation called for action. Group achievement soon put the electrical gun director of the Bell Telephone laboratories into action, taking the guesswork out of aiming and shooting the bombs down, and immediately the danger was brought under control. Group achievement hastens the progress of science and invention. To reward individual achievement only, and to discourage group action, would make reconversion of industry from war to peace a slow process.

To illustrate this point, attention is directed to *Fig. 4*, which shows the individual achievement of the inventor who developed and pioneered a new type of coal-cutting bit, one of the simplest yet most remarkable inventions in the coal-mining industry. On the left is the old type of bit, on the right the new, and in between are the bits which the inventor discarded in the progress of making the final invention. Development of the new bit started soon after the last war, the dates indicating the issuance of the patents upon the respective bits. The course which the inventor took to achieve the final product was a zig-zag line, as often is the case in invention until the goal is reached.

How a Successful Invention Evolved

In the mining of coal, a cleft is cut under the veins by a revolving series of cutting bits carried by the lugs of an endless power-driven chain. The bits are the most vital parts of the chain and are subject to a great deal of wear and abuse, sometimes being required to cut through rocks. The old type of bit shown at the left was made of one solid piece and when the bits became dull, which was frequently, they were sharpened by a blacksmith. Consequently coal cutting was slow and inefficient. The new bit is of a "Gillette" type, with a cutting point on each of the opposite ends and is held in the chain lug between a holder and a wedge by a set screw. The bit is discarded when both points become worn. Millions of these bits are now in use and, indirectly, are playing an important part in winning the war. Coal cutting is now fast, efficient and economical.

This new bit was made by individual achievement but it took substantially six years to develop it. With the aid

of group achievement and ample financial assistance, the inventor could have cut this time to one-half or less. Increased tempo of industry in the future will require such group activity.

In determining whether an inventor experienced the flash of genius, which depends entirely upon an evaluation of individual achievement, the court mentally attempts to reconstruct by hind-sight the steps which the inventor took in making the invention. Should the court experience no shock or surprise at the instant of reconstructing the inventive leap which the inventor made in creating the invention, then it is judicially concluded that the inventor also experienced no shock or surprise amounting to a flash of genius, in which event the patent would be held invalid.

Inventive Jump vs. Usefulness

With reference to *Fig.* 4, the amplitude of the zig-zag curve of inventions, that is, the lateral distance from one peak to the next, is the measure of the inventive jump or the extent of the flash of genius. The longitudinal component of the inventive jump is a measure of the *thing* invented, that is, a measure of improvement in a physical sense which the new device possesses over prior-art devices. Thus the inventive jump in a lateral direction may be large and yet constitute little scientific progress in the thing invented. The reverse situation is also true. Prior to Marconi's discovery, the greatest scientists and electrical wizards of the day were unable to send wireless messages much more than eighty miles. Marconi lengthened the arc around the world to six thousand miles—a longitudinal engineering achievement of great magnitude, yet the broad claims of his patent now are held to be unpatentable because the lateral amplitude of the flash of genius was considered to be too small. With present-day knowledge, school boys and mechanics now could perform what Marconi did in 1900.

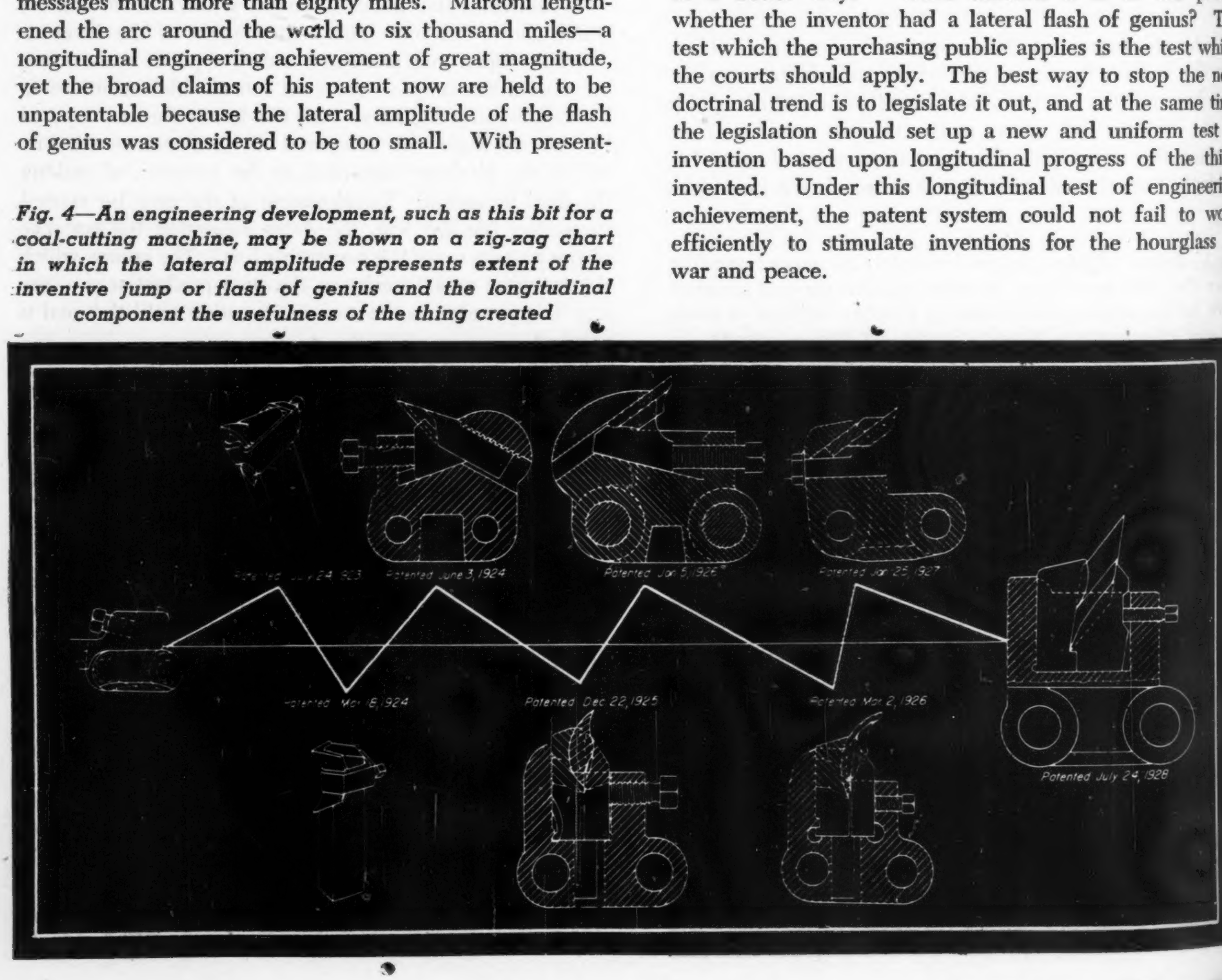
A major fault with the flash of genius test, and the reason why so many patents are declared invalid when applying this test, is that by the time the case gets to the Circuit Court of Appeals or to the Supreme Court (forty years in the case of the Marconi patent), the judges see the lateral amplitude of the zig-zag line of invention, which is a measure of the flash of genius, at too great a distance. The following words of Emerson help to explain why the Supreme Court and other courts which follow the new doctrinal trend are unable to apply accurately the flash of genius test:

> "The voyage of the best ship is a zig-zag line of a hundred tacks. This is only microscopic criticism. See the line from a sufficient distance, and it straightens itself to the average tendency."

Judging Invention by Longitudinal Merit

The distinction between lateral progress and longitudinal progress offers a possible solution for correcting our patent system to stimulate the creation of inventions. How much more accurate it would be to judge the longitudinal merit of the thing invented than to attempt to judge the lateral extent of the flash of genius. The customer or the purchasing public is interested only in the thing invented. The public wants to know: "Does the new device give improved results over the old? Does it function in a better way?" What concern is it to the public whether the inventor had a lateral flash of genius? The test which the purchasing public applies is the test which the courts should apply. The best way to stop the new doctrinal trend is to legislate it out, and at the same time the legislation should set up a new and uniform test of invention based upon longitudinal progress of the thing invented. Under this longitudinal test of engineering achievement, the patent system could not fail to work efficiently to stimulate inventions for the hourglass of war and peace.

Fig. 4—An engineering development, such as this bit for a coal-cutting machine, may be shown on a zig-zag chart in which the lateral amplitude represents extent of the inventive jump or flash of genius and the longitudinal component the usefulness of the thing created



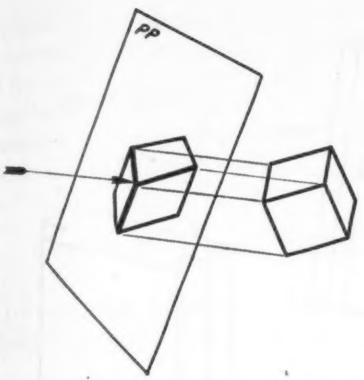


Fig. 1—Left—Isometric projection of a cube

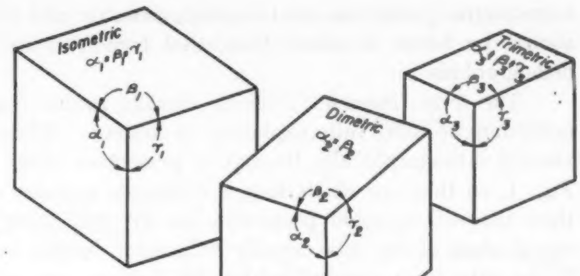


Fig. 2—Right—Angles and axes of a cube in axonometric projections, one axis vertical in each view

Trimetric Drawing— Its Theory and Technique

By George F. Bush
School of Engineering, Princeton University

IMPORTANCE of trimetric projection is shown by the ever-increasing use of, and demand for, pictorial drawings in the field of engineering. Such drawings are useful for rapid and intelligible shape-description of objects in assembly shops, in service and instruction manuals and catalogs, and in sales displays. They figure prominently in design, proposals, master layouts, purchasing, subcontracting, installation, and instruction. Among their miscellaneous applications may be mentioned three-dimensional graphs. When they are being made scientifically, they are always under the control of their creator. For this reason they are sometimes superior to photographs which are often found unsatisfactory because shadows obscure important parts, highlights often emphasize unimportant parts, nonessential parts may be shown, and details may be lost. Pictorial drawings produce a rapid reaction that arouse interest which might otherwise remain dormant; they hasten a meeting of minds.

All pictorial projections are either axonometric, oblique, or perspective. Axonometric projections are orthographic, but they differ from the conventional three-plane orthographic projections in that only one projection plane is necessary to describe the object. The only branches of

Based on the author's forthcoming book, *Engineering Pictorials*, soon to be published.

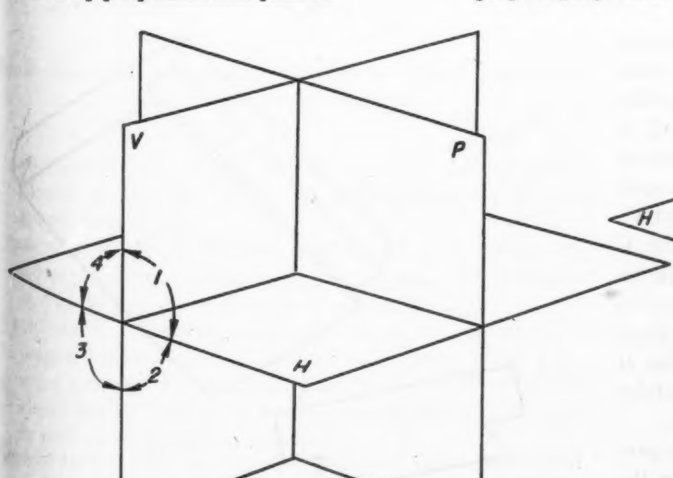


Fig. 3—Indication of quadrants formed by perpendicular planes

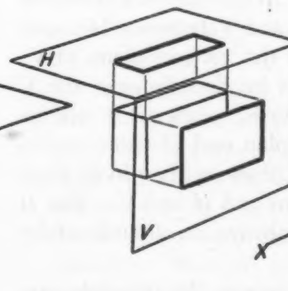


Fig. 4 — Conventional orthographic projection in quadrant 3

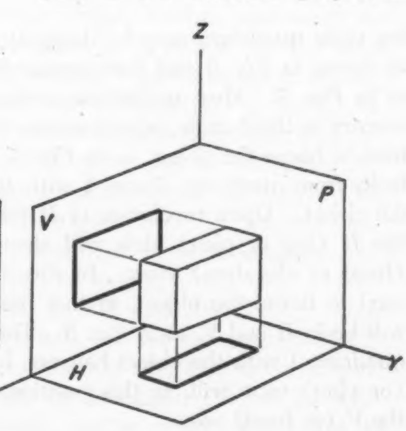


Fig. 5—Object is housed in quadrant 1 for trimetric projection

axonometric projection are isometric, dimetric and trimetric. It should be borne in mind, then, that trimetrics are one-plane orthographics.

The term "isometric", which literally means "equal measure", may be more fully explained as follows: When a cube is viewed orthographically through a projection plane *PP*, as in *Fig.* 1, so that one of its longer diagonals appears as a point, then the orthographic projection on *PP* will show the three equal edges of the cube equally reduced in length, as in *Fig.* 2. If the cube is so oriented behind *PP* that any two of the edges are equally reduced, dimetric projection results. If all three edges project unequally the result is trimetric, *Fig.* 2. It should be noted that any angle between the axes is greater than 90 degrees; also, that none of the axes need be vertical.

One advantage of trimetric is that any plane of the object may be emphasized. One disadvantage, relative to perspective, is its slight distortion.

Relationship of Three-Plane and One-Plane Projection: The three mutually perpendicular projection planes form-

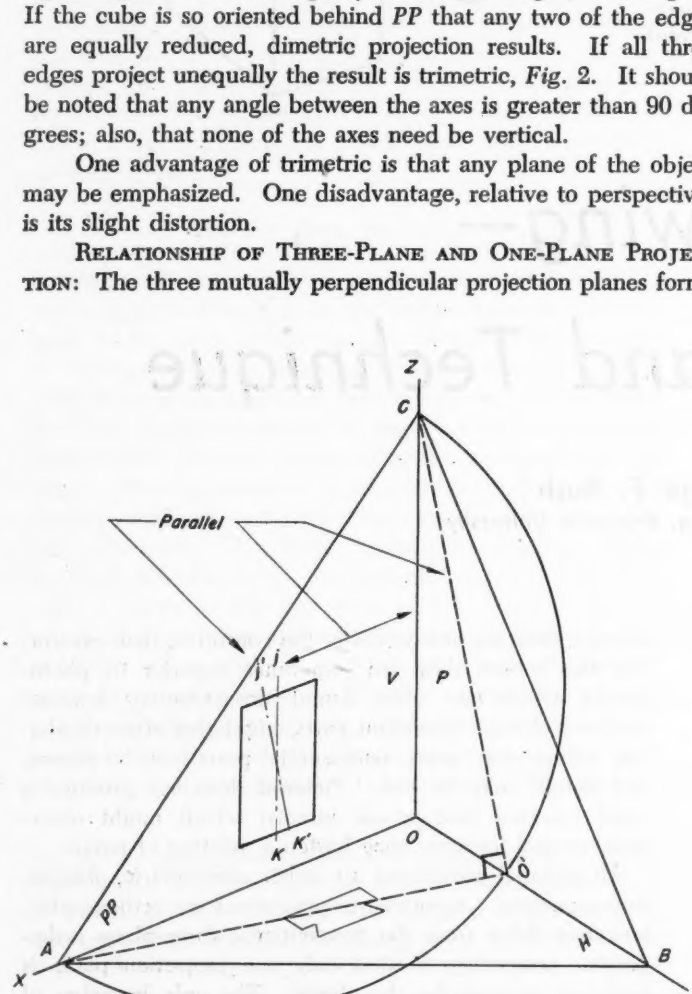


Fig. 6—Representation of plane PP for trimetric projection. Object is housed in quadrant behind plane

ing eight quadrants may be designated the *V*, *P* and *H* planes as shown in *Fig.* 3 and their intersections the *X*, *Y* and *Z* axes, as in *Fig.* 5. Most multiplane orthographic projection in this country is third-angle, which means that quadrant 3, *Fig.* 3, is used to house the object, as in *Fig.* 4. In this case the observer looks from quadrants 2 and 4 with *H* and *V* between him and the object. Upon revolution of *H* into the vertical plane of *V*, the *H* (top or plan) view will always be directly over the *V* (front or elevation) view. In this article, quadrant 1 will be used to house the object, so that the plan and elevation views will be in *H* and *V*, as in *Fig.* 5. The observer then looks from quadrant 1 with the object between him and *H* and *V*. The *H* (or plan) view will, in this position, always be directly *under* the *V* (or front) view.

In *Fig.* 6, let *PP*, on which will appear the trimetric projection, be placed in front of the object and intersecting the quadrant 1. In this case, the observer looks from quadrant 1

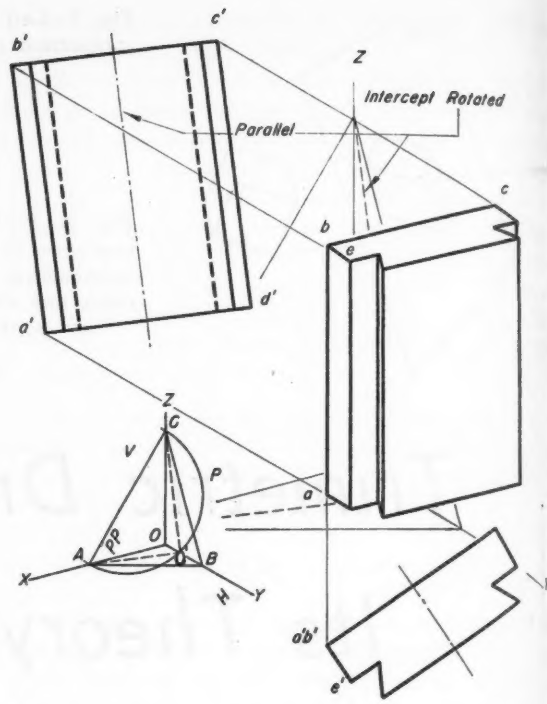
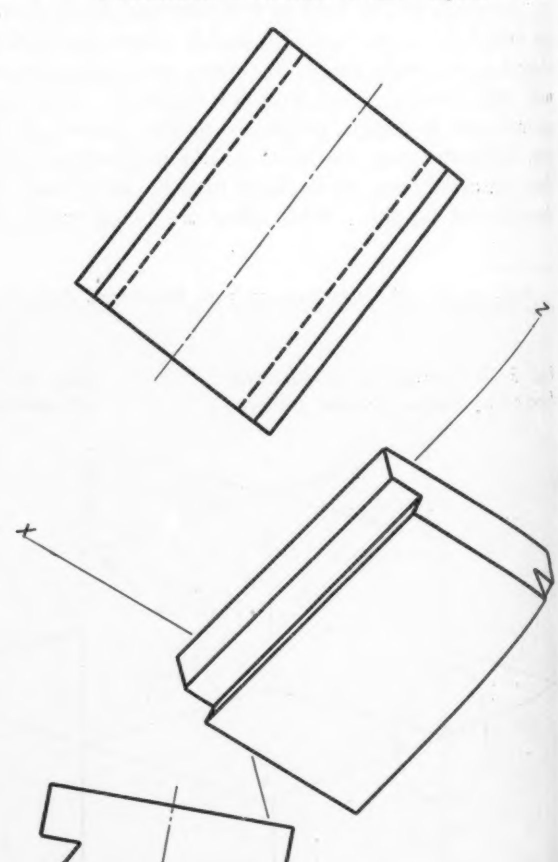


Fig. 7—Above—Trimetric projection by Method 1

Fig. 8—Below—Variation of Fig. 7 by rotation to accentuate a feature of the object



through *PP* and at the object on the other side of *PP*. In other words, *PP* is between the observer and the object. If the object were shown in *Fig.* 6, it would be in the region bounded by the *H*, *V*, *P*, and *PP* planes. Only the trimetrics of the three-plane *H* and *V* views have been shown in *Fig.* 6, the *P* view having been omitted.

Principles of Geometry Applying to Projection

Geometrical Principles: Principles of geometry applying to projections may be briefly stated as follows:

Principle 1: Any triangle inscribed in a semicircle, whose diameter equals one side of the triangle, is a right triangle

Principle 2: Parallel lines in space (or in the object) appear parallel in any orthographic view

Principle 3: In any orthographic view, a line that is per-

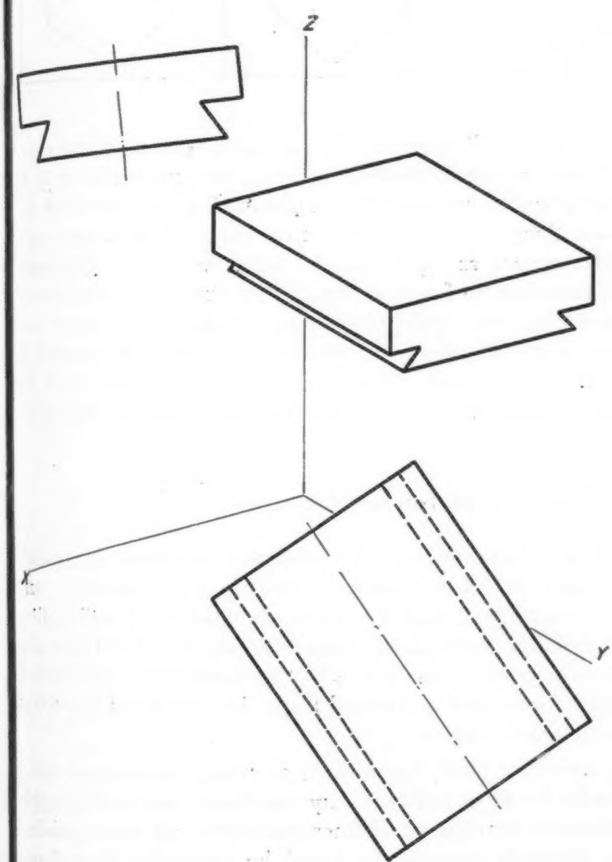


Fig. 9—Another projection variation of Fig. 7 indicating the variety of viewpoints

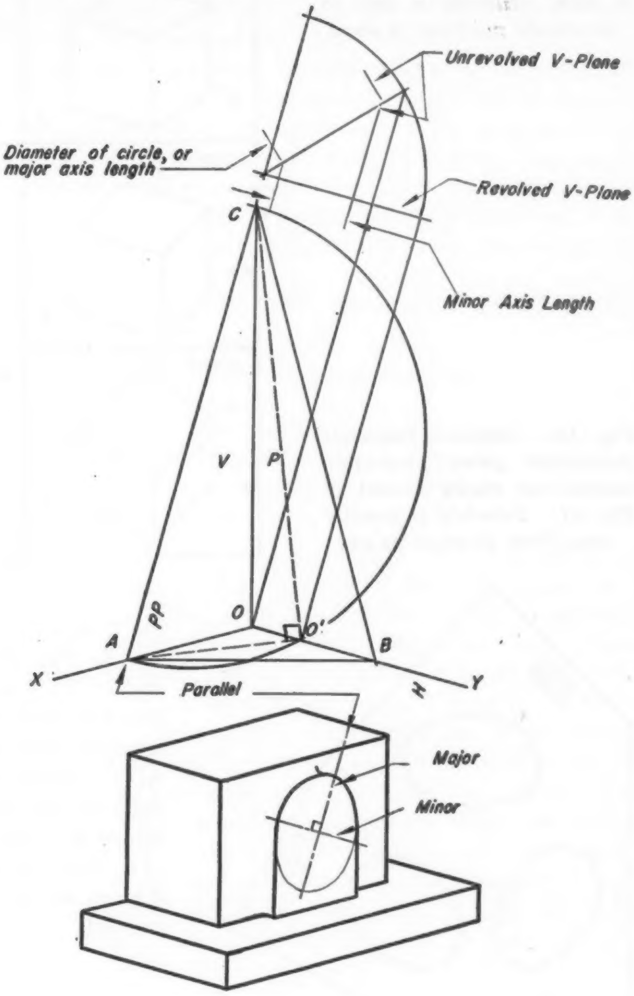
pendicular to an oblique plane in space shows perpendicular to any line on the plane that shows in its true length in that view

Principle 4: A point, when revolving in space, always revolves about some straight line as an axis. For example, in *Fig.* 10 line *AC* is the axis of revolution.

Principle 5: A point always revolves in a plane which is perpendicular to the axis and its path in this plane is always a circle. For example, point *O* in *Fig.* 10, revolving about axis *AC*, moves in a plane perpendicular to *AC* and its path of revolution is a circle

Principle 6: The circular path of a point in revolution will always appear as a circle in the view which shows the axis of revolution as a point. For example, in *Fig.* 10,

Fig. 10—Below—Projection produced by superposition method. This is useful for simple drawings



the path of *O* in revolution appears as a circular arc in the view showing axis *AC* as a point

Principle 7: The circular path of a point in revolution will always appear as a straight line perpendicular to the axis in the view which shows the true length of the axis. For example, in *Fig.* 10 point *O* moves along line *BO'* which is perpendicular to line *AC*.

Viewing Plane Intercepts Axes Unequally

Trimetric Projection: When *PP* has been made to intersect the quadrant 1, as in *Fig.* 6, so that the *X*, *Y* and Z intercepts (or *OA*, *OB*, and *OC*) are all unequal, the resulting axonometric on *PP* will be trimetric. It should be remembered that, since the orthographic projection is on *PP* and the projection will be portrayed on the paper, *PP* is the paper itself. From Principle 3, *OB* will be perpendicular to *AC* in the orthographic view *PP*, because line *OB* is perpendicular to the oblique plane *V* in space and line *AC* on *V* shows in its true length in this view. Likewise, *OC* is perpendicular to *AB*, and *AO* to *BC*. This perpendicularity relationship is true for any position of *PP* intersecting the quadrant, that is to say, once the *X*, *Y* and *Z* axes have been drawn, the triangular *PP* can be constructed. This *PP* triangle can be of any size. For a given set of axes, all *PP* triangles will be similar and similarly placed.

It is to be noted from the foregoing that the intercepts

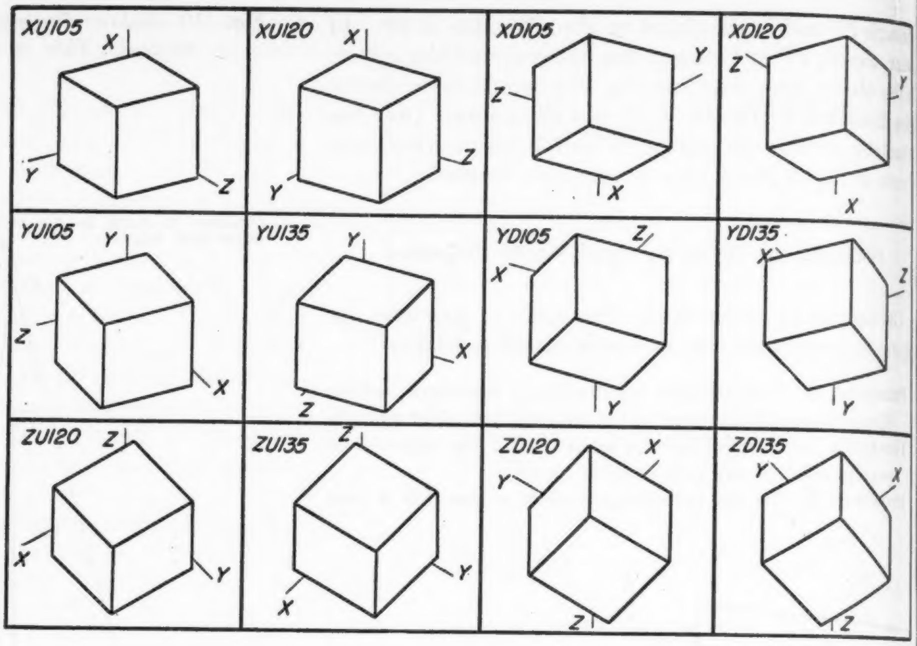
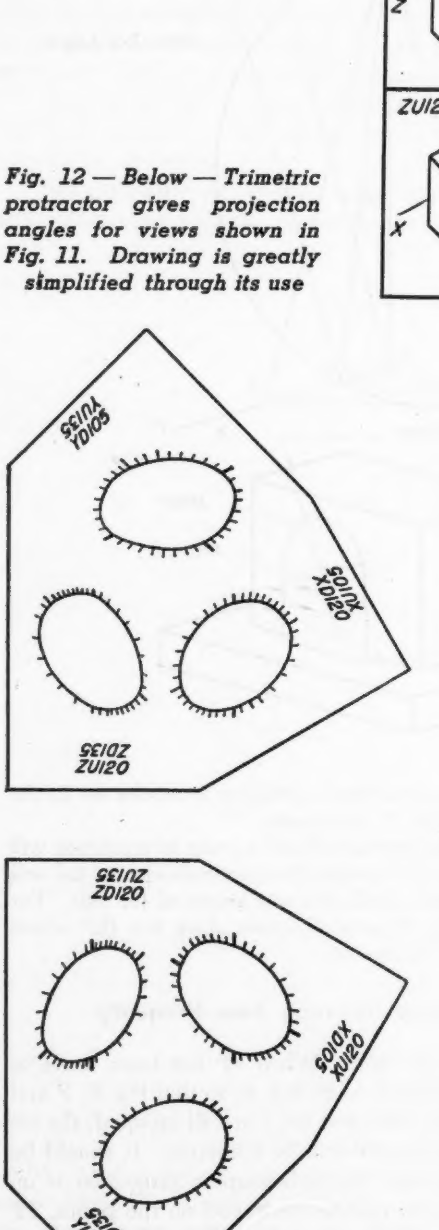


Fig. 11—Right—System of twelve trimetric positions for a cube, utilizing a key to designate position of each

Fig. 12 — Below — Trimetric protractor gives projection angles for views shown in Fig. 11. Drawing is greatly simplified through its use



OA, *OB* and *OC* drawn on the paper are trimetrics of the space axes *X*, *Y* and *Z*. Likewise, the *V* and *H* views shown in *Fig*. 6 are trimetrics of the *V* and *H* views of the three-plane system. Also, in space, a centerline of a three-plane view like *jk* of the *V* view is usually parallel to one of the axes, in this case the Z axis. By Principle 2, *jk* and the Z axis (or *OC*) in *Fig*. 6 will therefore be parallel in this trimetric view.

In *Figs*. 6 and 10 also are demonstrated the revolution principles 4, 5, 6, and 7. They show that when the space right triangle *AOC* is rotated about *AC* into *PP*, point *O* moves along *OB* to *O'*. The true shape of the space right triangle *AOC* will then appear as right triangle *AO'C* with the right angle *AO'C*. Point *O'* can therefore be found as the intersection of a semicircle of diameter *AC* with the *Y* axis (Principle 1). During revolution, the space centerline *jk* of *Fig*. 6 moves to *j'k'* where, by Principle 2, it must be parallel to *O'C*, which is the Z intercept rotated. Whatever size *PP* triangle is used, for a given set of axes, the corresponding *X*, *Y* and Z intercepts rotated will all be parallel.

Technique of Trimetric Projection

One can see that an infinite number of axonometric positions is possible. These positions have been classified isometric, dimetric and trimetric. Any trimetric may now be constructed and the following Method 1 will outline a general construction from the three-plane views of an object. For those who prefer a reduction from the general case into a few trimetric positions, Method 2 is presented. It will be seen that in Method 2 the dimensions of the object are used in a slightly different manner.

METHOD 1: As noted by Hoelscher, drawn or cutout three-plane views may be used in this method. If, as in *Fig*. 7, any two three-plane orthographic views are drawn or placed with their centerlines parallel to the corresponding intercept rotated, the trimetric view can be found by projection lines drawn from these orthographics and parallel to another intercept. For example, in *Fig*. 7 the three-plane *V* view has been placed with its vertical centerline parallel to the Z intercept rotated as explained. Likewise, the three-plane *H* view has been placed with its centerline parallel to the *Y* intercept rotated. Point *a* in the trimetric is the intersection of the two projection lines, one drawn from *a'* in the *V* view, parallel to the *Y* axis, and the other drawn from *a'* in the *H* view parallel to the Z axis. The trimetric of the point *b*, determined in the same way, will determine the trimetric of the space line *ab*. Such synthesis from points to lines to surfaces will determine the trimetric of the object. It should be noted that only two views are required.

View in *Fig*. 8 is simply *Fig*. 7 rotated. Another different view may be obtained from new three-plane orthographic views which must be derivable from the new orientation of the object in the quadrant. Compare *Fig*. 9 with *Fig*. 7. Another method of obtaining a different

view of the object is by changing the angles between the axes. In trimetric, the angles are unequal and may be of any value, depending upon the desired pictorial view, *Fig.* 2. Trimetrics showing the bottom view of an object are often useful.

It is important to note that, once the angle of a three-plane orthographic view has been determined in Method 1, it alone need be maintained. This means that the positions of these views may be shifted in order to obtain the trimetric in some particular position on the paper, but in so doing be sure to maintain the angle. This shifting property is of special importance in making *exploded* trimetrics.

That the three-plane orthographics can be shifted makes possible the application of the superposition method by

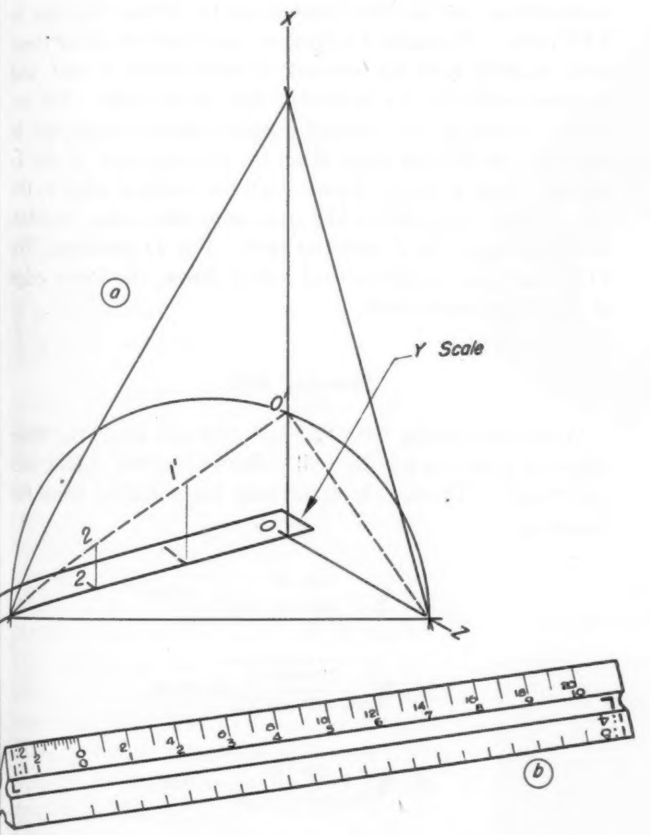


Fig. 13—Graphic determination of scales is shown at (a) for a standard trimetric scale at (b)

which two such views may be used under a transparency, such as tracing paper, on which the trimetric is to be drawn. Here the views need not be cut from the engineering drawing, nor drawn in position on the paper which will show the trimetric. For instance, the front view on the engineering drawing containing the three-plane orthographics is placed under the tracing paper at the proper angle and desired position, and the projection lines drawn; then the same procedure is followed for, say, the top view. For convenience, all projection lines of the same direction should be drawn before those of the other direction.

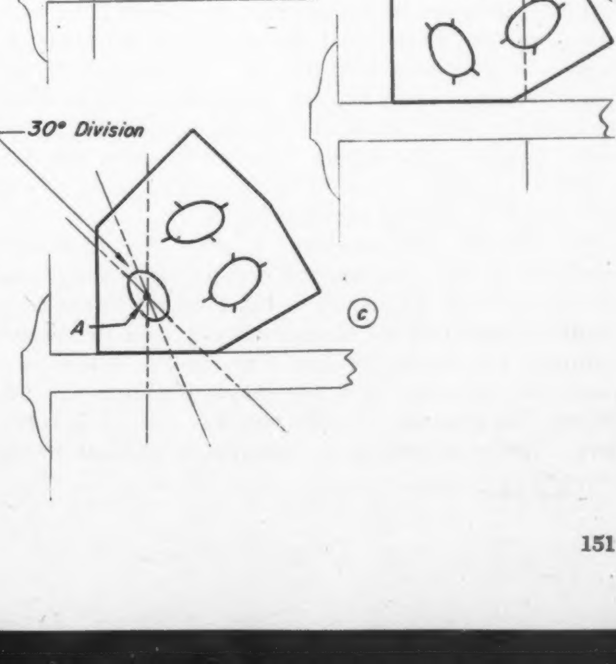
If this is done, some confusion may arise with the more complex objects, even though the lines are labeled, and superposition is therefore not recommended for such complex objects. Of course, in order to avoid such confusion, a few projection lines of each direction could be drawn and their trimetric intersection points determined. This would require two settings of the three-plane drawing under the tracing paper. The procedure would be repeated for a few more projection lines of the two directions, thus requiring two more settings, and so on until the trimetric would be completed. If too many resettings are required, as with some complex objects, then superposition is not recommended. It is recommended for simple objects. *Fig.* 10, exclusive of the ellipse, was made by the superposition method, using only one setting for each of the two views.

Summarizing briefly, the procedure for making a trimetric by Method 1 is:

1. Determine the axes for the desired view
2. Draw the *PP* triangle
3. Determine the necessary revolved intercepts
4. Place or draw the three-plane orthographic views
5. Project from the three-plane orthographics to obtain the trimetric.

A circle in a plane not parallel to *PP* will appear as an ellipse, as indicated in *Fig.* 10. If the circle appears in a three-plane orthographic view, the length and direction of the major and minor axes of the ellipse can easily be determined, once the center has been found. As there indicated, the major axis will have a length equal to the diameter of the circle and the direction is that of the axis of revolution *AC* used to rotate the space plane *AOC* into *PP* where the space circle will then appear as a circle. The minor axis will be perpendicular to the major axis and its length may be determined from a view showing the forementioned axis as a point, according to Principles 4, 5, 6, 7 and *Fig.* 10. In *Fig.* 10 the triangle *AOC* is seen as an edge when the axis *AC* is seen as a point, no matter if *AOC*

Fig. 14—Below—Use of trimetric protractor shows simplicity of application in determining projection angles



is in the revolved or unrevolved position (think of the *PP* view as a plan and the view above it showing the circular arc as an elevation view related to it). *Fig.* 10 also shows how the revolved and unrevolved positions of *AOC* may be obtained. The diameter of the circle may be laid off in the unrevolved plane at any convenient position along the plane, so that the length of the minor axis may be obtained as shown. Having obtained the major and minor axes in length and direction, one can use any of the standard methods for drawing an exact or approximate ellipse, depending on the requirements. Mechanical devices for drawing ellipses, such as ellipsographs and ellipse guides, will be discussed later.

METHOD 2: To simplify the trimetric drawing of most objects, a definite number of trimetric positions may be chosen from the infinite number possible. Assuming the object to be a cube the twelve positions shown in *Fig.* 11

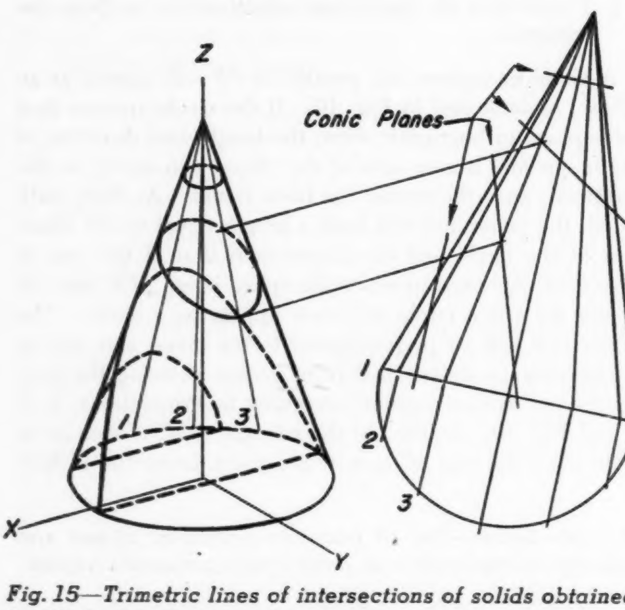


Fig. 15—Trimetric lines of intersections of solids obtained by Method 2. Orthographic intersections are unnecessary

are chosen. All positions show the cube's edges parallel to the *XYZ* axes with one edge always vertical; the axes are right hand and angles between them are 105, 120 and 135 degrees. Designation of any of these twelve positions will be simplified by a notation like ZU120, which designates the position shown lower left in *Fig.* 11. The first letter indicates the vertical axis, the second letter indicates "up" or "down", and the number is the angle, in degrees, to the next axis on the left. The notation ZU120 would therefore mean that the Z axis is vertical and up; and that the angle between it and the next axis to the left —the *X* axis—is 120 degrees. The three angles, 105, 120 and 135, were chosen chiefly because they can be drawn with standard drafting equipment.

The trimetric liner-protractor* shown in *Fig.* 12 may be used to draw the three trimetric axes in any of the twelve positions of *Fig.* 11. Once it has been set in the right position relative to the T-square for any of the twelve positions, the correct drawing of the axes is almost automatic and foolproof, if a few simple directions are followed. No reference to a drawing like *Fig.* 11 is necessary. Before describing it, attention is directed to the *XYZ* order, in a counterclockwise direction, of the axes in *Fig.* 11. This means that these letters are to be read in order no matter which one of the three is first. For example, in the position lower left of *Fig.* 11, if one reads the axes counterclockwise from, say, the Z one, then one would read the Z, *X* and *Y* axes in *XYZ* order.

The liner-protractor has the shape of an irregular polygon in which every other interior angle is a right angle. On each side every other edge is marked with one of the trimetric positions of *Fig.* 11. These edges are called "position edges". The other three edges, parallel to the axes when the instrument is positioned and which may be used to draw the axes, are unmarked. The proper position edge is laid against either the top or bottom edge of the T-square and the axes are then drawn for any of the twelve positions, regardless of the position, going counterclockwise on the liner-protractor to obtain the axes in *XYZ* order. Unmarked edges are used only to draw these axes, starting with the unmarked edge which is next, and perpendicular to, the position edge being used. For example, to obtain the XU105 position shown upper left in *Fig.* 11, the XU105 edge is set on the top edge of the T-square. The *X* axis is drawn with the vertical edge to the left. The Y axis will be the next unmarked edge counterclockwise and the Z axis the next. For D positions, like YD135, in which the vertical axis is down, the lower edge of the T-square is used.

*Patent applied for.

Drawing Aids

When the angles 105, 120 and 135 are used, the three edges of a one-inch cube will reduce to .9194, .8556, and .6501-inch. These reductions may be obtained from the formulas

$$L=\sqrt{\frac{\cos 45^\circ}{\cos 30^\circ \cos 15^\circ}}=.9194$$

$$M=\sqrt{\frac{\cos 60^\circ}{\cos 45^\circ \cos 15^\circ}}=.8556$$

$$S=\sqrt{\frac{\cos 75^\circ}{\cos 45^\circ \cos 30^\circ}}=.6501$$

These reductions may also be obtained graphically as indicated in *Figs.* 7 and 13*a*. In *Fig.* 7, which uses position ZU120, the true lengths $b'c'$, $b'e'$ and $a'b'$ have been reduced by Method 1 to *bc*, *be* and *ab*, respectively. Reductions calculated from measurement of these lengths will compare favorably with those calculated from the formulas.

How a working scale may be constructed for any of the twelve trimetric positions is indicated in *Fig.* 13*a*. Such a scale is shown in *Fig.* 13*b*. It contains three faces marked *L*, *M* and *S*, corresponding to the long, medium and short edges of the reduced cube. The *L* scale, for example, will represent one inch on the object as .9194-inch on the drawing, provided the 1:1 part of the *L* face is used. There are four such parts on each face of the scale and each is marked 1:1, 1:2, 1:4, and 1:8. Fractional parts of an inch, such as ½, ¼, etc., of an inch, are indicated. Scale 1:1 means that the trimetric made using this part of the scale will be "full size". If the 1:2 scale is used, the

(*Concluded on Page* 196)

Analyzing the Strength of Curved Beams

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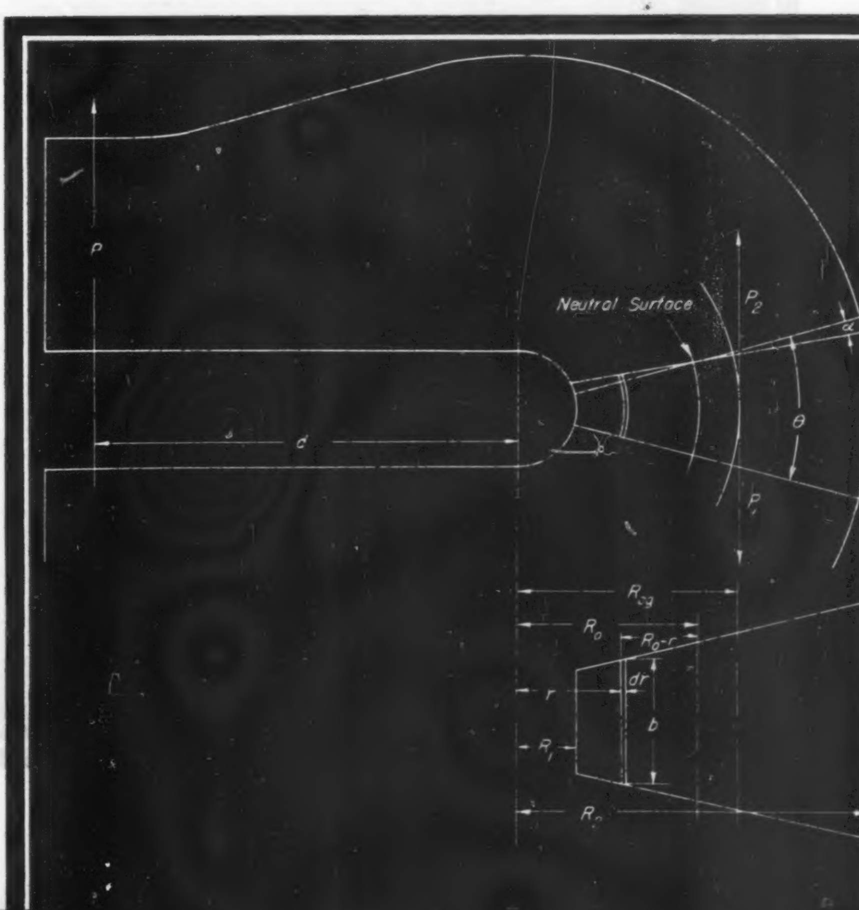
Part I—Basic Equations

Fig. 1—Accurate knowledge of the stresses in curved beams, such as the yoke of this portable rivet squeezer, enables these components to be designed for minimum weight. — Photo, courtesy The Cleveland Pneumatic Tool Co.

BEAMS with initial curvature find an important place in certain types of machines, notably portable riveters, *Fig.* 1, and punch presses, as well as parts such as crane hooks, curved links and other heavily loaded machine components. As is commonly recognized, the usual formulas for calculating beam strength give only a rough approximation to the actual stress if the radius of curvature is comparable in size to the depth of the beam. This is because the tangential stress distribution is not linear and the common beam formula $M = SI/c$ no longer applies. Brief consideration of the portion of a curved beam shown in *Fig.* 2 will show why this is so: Although actual deformations may be directly proportional to distance from the neutral axis, the initial lengths upon which these deformations are based are much less at the inside radius than at the outside radius. As a result the unit deformations, upon which the elastic stress depends, are proportionately higher at the inside fibers.

By drawing radial lines normal to the neutral axis of the beam, formulas for determining the tangential stresses have been derived, and are now incorporated in most books on strength of materials and machine design. Although these formulas give the tension forces at the inner and outer radius of curvature, many failures have occurred by radial tension, or by a combination of radial tension and shear. This article presents

Fig. 2—Below—The stress distribution in curved beams is calculated on the assumption that the total deformation in the tangential direction is directly proportional to the distance from the neutral surface.



new formulas for the latter types of stress.

Derivations of the formulas which follow will include those for tangential stresses as well as for radial tension stresses, shearing stresses, and the combination of shear and radial tension stresses, so that a curved member may be designed to withstand all combinations. By using these formulas the design of curved beams becomes only slightly more laborious than for straight machine members.

To facilitate the discussion, the punch press frame shown in *Fig.* 2 will be used as an example. The general formulas derived, however, are applicable to any curved beam design. An applied load P at the center of the punch induces bending stresses throughout the frame, the critical sections lying in the horizontal plane and the upper vertical plane.

Tangential Stress: Substituting loads P_1 and P_2 at the center of gravity, *Fig.* 2, each equal to the load P, gives a uniform tension stress (see Nomenclature)

$$S_t=\frac{P_2}{A}=\frac{P}{A} \qquad (1)$$

The loads P and P_1 form a couple whose moment is

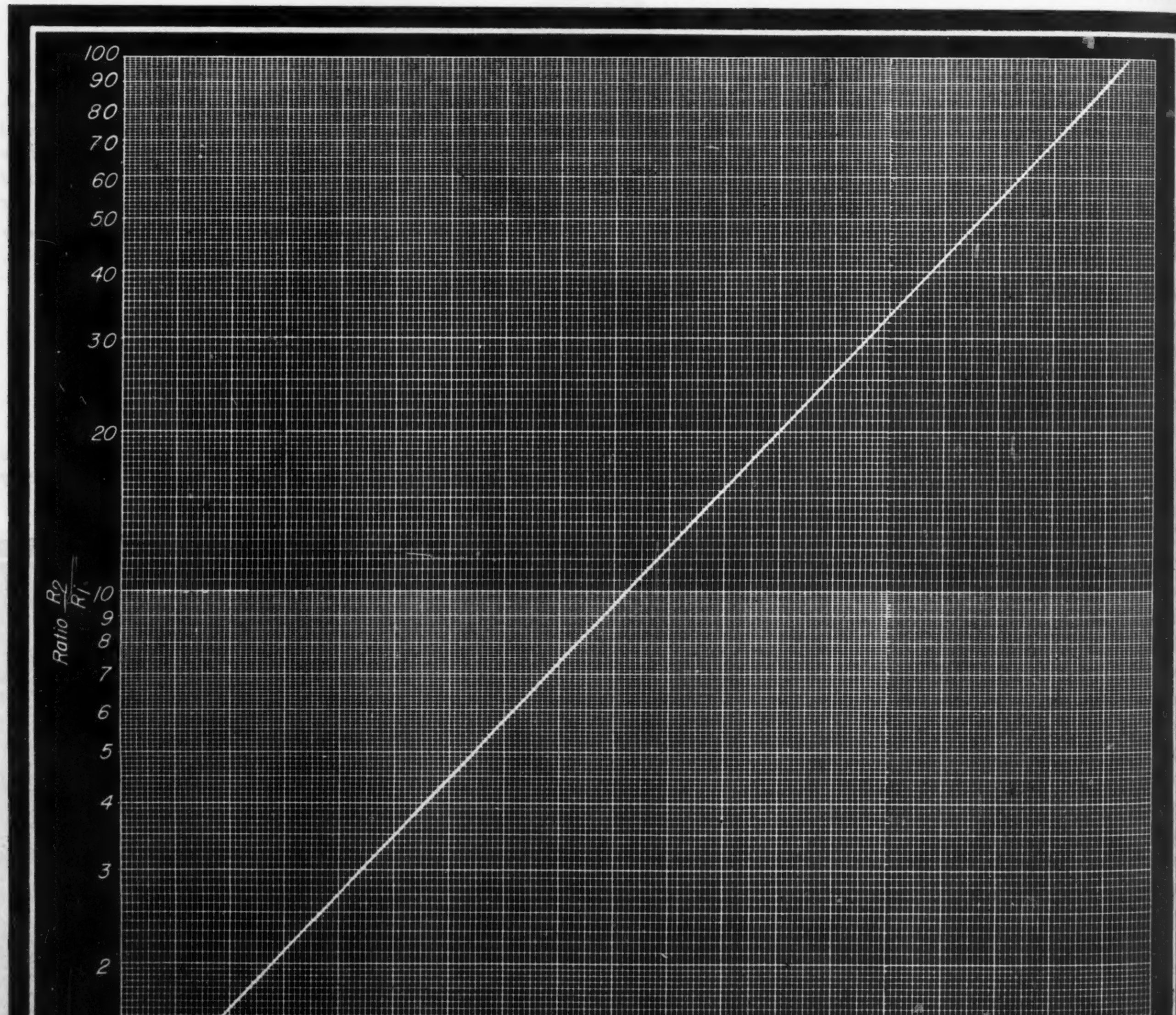
$$M=P(d+R_{cg})$$

This moment results in a tension inside the neutral surface and a compression outside this surface. The unit deformation at radius r is

$$\frac{(R_o-r)\alpha}{r\theta}$$

The stress is

Fig. 3—Chart for hyperbolic logarithms may be used in evaluating R_0 for sections which are built up of rectangles



$$S=\frac{(R_o-r)\alpha E}{r\ \ \theta}=k\frac{R_o-r}{r} \quad \text{.......................... (2)}$$

The force on the differential area dA ($dA=bdr$) is

$$dF=k\left(\frac{R_o-r}{r}\right)dA$$

Integrating

$$F=k\int_{R_1}^{R_2}\frac{R_o-r}{r}dA \quad =k\left(R_o\int_{R_1}^{R_2}\frac{dA}{r}-A\right)$$

Since there is no resultant direct tension or compression due to bending, the tension and compression forces due to bending are equal and

$$k\left(R_o\int_{R_1}^{R_2}\frac{dA}{r}-A\right)=0 \quad ; \quad R_o\int_{R_1}^{R_2}\frac{dA}{r}=A$$

$$R_o=\frac{A}{\int_{R_1}^{R_2}\frac{dA}{r}} \quad \text{..................................... (3)}$$

Evaluation of the integral in the denominator of Equation 3 depends upon the relation between b and r for the type of cross section used in the beam, inasmuch as $dA = b\ dr$. For a rectangular section, b is constant and

$$\int_{R_1}^{R_2}\frac{dA}{r}=\int_{R_1}^{R_2}\frac{b\ dr}{r}=b\ \log_e\frac{R_2}{R_1}$$

Because weight saving usually is a consideration in design, box, T or I-sections are preferred, and since these are made up of rectangles the evaluation is relatively simple, as explained later in the worked example. Values of $\log_e(R_2/R_1)$ are plotted in *Fig.* 3.

Sections other than rectangular may be divided approximately into rectangles and solved in a similar manner to that employed in the worked example.

Taking moments about the center of curvature,

$$+dM=-rdF=-k(R_o-r)dA$$

Nomenclature

- θ = Angle between reference radii before loading
- α = Change of angle θ due to load
- A = Total area of section
- b = Breadth at dA
- B = Breadth at radius R
- d = Distance from center of curvature to center line of load (depth of throat)
- dA = Differential area = bdr
- E = Modulus of elasticity
- F = Total force on section
- k = $E\alpha/\theta$
- P = Load
- r = Radius of dA
- R = Radius of a particular section
- R_1 = Inner radius of section
- R_2 = Outer radius of section
- R_{cg} = Radius to center of gravity of section
- R_o = Radius neutral axis
- S = Stress at radius r
- S_c = Compression stress
- S_s = Shearing stress
- S_t = Tension stress
- S_s' = Maximum shear resulting from tension and shear
- S_t' = Maximum tension resulting from tension and shear

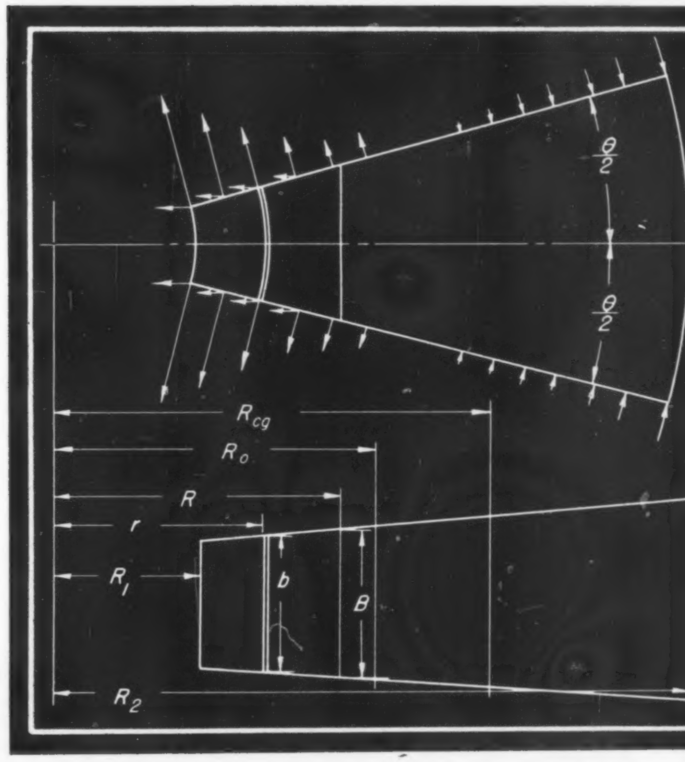


Fig. 4—Radial stresses in curved beam are due to inclination of tangential tensile and compressive stresses

Integrating

$$+M=k\left(\int_{R_1}^{R_2}rdA-R_oA\right)=kA(R_{cg}-R_o)$$

$$k=\frac{M}{A(R_{cg}-R_o)}=\frac{P(d+R_{cg})}{A(R_{cg}-R_o)} \quad \text{.................. (4)}$$

From Equations 1, 2 and 4 the total tangential stress at R_1 is

$$S_t=\frac{P}{A}+\frac{P}{A}\ \frac{(d+R_{cg})}{(R_{cg}-R_o)}\ \frac{(R_o-R_1)}{R_1}$$

$$S_t=\frac{P}{A}\left[1+\frac{(d+R_{cg})}{(R_{cg}-R_o)}\ \frac{(R_o-R_1)}{R_1}\right] \quad \text{................ (5)}$$

Also the compression stress at R_2 is

$$S_c=\frac{P}{A}\left[\frac{(d+R_{cg})}{(R_{cg}-R_o)}\ \frac{(R_2-R_o)}{R_2}-1\right] \quad \text{................ (6)}$$

Radial Stress: The tangential force dF on the differential area dA is

$$dF=k\frac{R_o-r}{r}dA$$

Radial component of this force, *Fig.* 4, is

$$dF_{radial}=k\frac{R_o-r}{r}dA\ \sin\frac{\theta}{2}$$

Total radial force exerted on the section between R_1 and R is

$$F_{radial}=2k\ \sin\frac{\theta}{2}\left[\int_{R_1}^{R}\frac{R_o-r}{r}dA\right]$$

$$F_{radial}=2k\ \sin\frac{\theta}{2}\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}$$

This radial force is resisted by the area 2 $BR\ \sin\ \theta/2$, therefore

$$S_{radial}=\frac{2k\ \sin\frac{\theta}{2}\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{2BR\ \sin\frac{\theta}{2}}$$

$$S_{radial}=\frac{k\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{RB}$$

Substituting the value of k from Equation 4 gives

$$S_{radial}=\frac{P(d+R_{cg})\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{A(R_{cg}-R_o)RB}\quad\ldots\ldots\ldots\ldots\ldots(7)$$

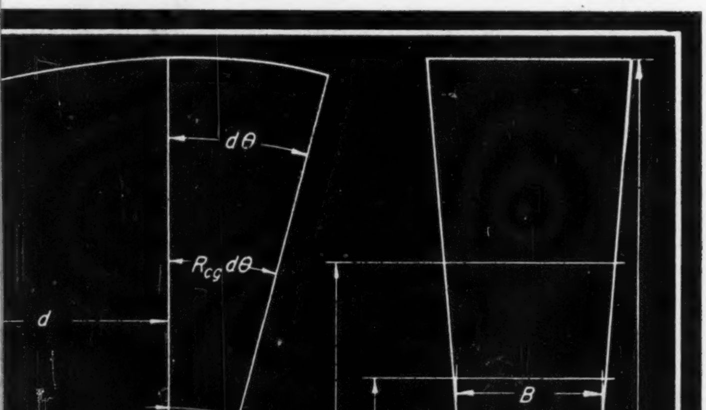
The vertical section, *Fig.* 5, which is above the center of curvature, carries no direct tension and the moment is Pd instead of $P\ (d+R_{cg})$; therefore Equation 5 for the tension at R_1 becomes

$$S_t=\frac{Pd}{A(R_{cg}-R_o)}\ \frac{(R_o-R_1)}{R_1}\quad\ldots\ldots\ldots\ldots\ldots(8)$$

Equation 6 for compression at R_2 becomes

$$S_c=\frac{Pd}{A(R_{cg}-R_o)}\ \frac{(R_2-R_o)}{R_2}\quad\ldots\ldots\ldots\ldots\ldots(9)$$

Fig. 5—Shear stress in vertical section is important



Equation 7 for radial tension at R becomes

$$S_{radial}=\frac{Pd\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{A(R_{cg}-R_o)RB}\quad\ldots\ldots\ldots\ldots\ldots(10)$$

Shearing Stress in Vertical Section: Using Equation 8, the horizontal force dF on the differential area dA above the center of curvature is

$$dF=\frac{Pd}{A(R_{cg}-R_o)}\ \frac{(R_o-r)}{r}dA$$

The horizontal force on the left side of this section between R and R_1 is

$$F_l=\frac{Pd}{A(R_{cg}-R_o)}\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}$$

and the horizontal force on the right side of this section between R and R_1 is

$$F_r=\frac{P(d+R_{cg}d\theta)}{A(R_{cg}-R_o)}\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}$$

The difference between these forces is resisted by the area $RB\ d\theta$, and the shearing stress at R is

$$S_s=\frac{P\,R_{cg}d\theta\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{A(R_{cg}-R_o)RB\ d\theta}$$

$$S_s=\frac{P\,R_{cg}\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{A(R_{cg}-R_o)RB}\quad\ldots\ldots\ldots\ldots\ldots(11)$$

Maximum shearing stress is obtained by combining the radial tension from Equation 10 and the horizontal and vertical shear from Equation 11:

$$S_s'=\sqrt{S_s^2+\left(\frac{S_{radial}}{2}\right)^2}$$

$$S_s'=\frac{P\sqrt{R_{cg}^2+\left(\frac{d}{2}\right)^2}\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{A(R_{cg}-R_o)RB}\quad\ldots\ldots(12)$$

Maximum tension resulting from Equations 10 and 11 gives

$$S_t'=\frac{S_{radial}}{2}+S_s'$$

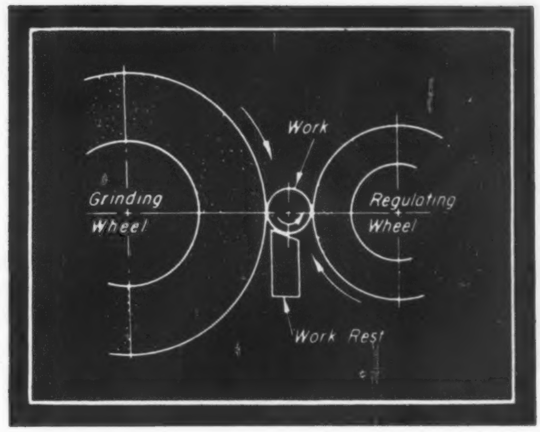
$$S_t'=\frac{P\left[\frac{d}{2}+\sqrt{\left(\frac{d}{2}\right)^2+R_{cg}^2}\right]\left[R_o\int\frac{dA}{r}-A\right]_{R_1}^{R}}{A(R_{cg}-R_o)RB}\quad.(13)$$

If desired, the stresses may be found on any section between the horizontal and the vertical. However, if the sections between the horizontal and the vertical are laid out without abrupt cross-section changes there will be no necessity for further calculations.

In the second, and concluding article the equations derived in the foregoing will be applied to the solution of a specific problem involving the design of a curved beam forming part of a machine frame.

By Louis Dodge

Basic Principles of Centerless Grinding



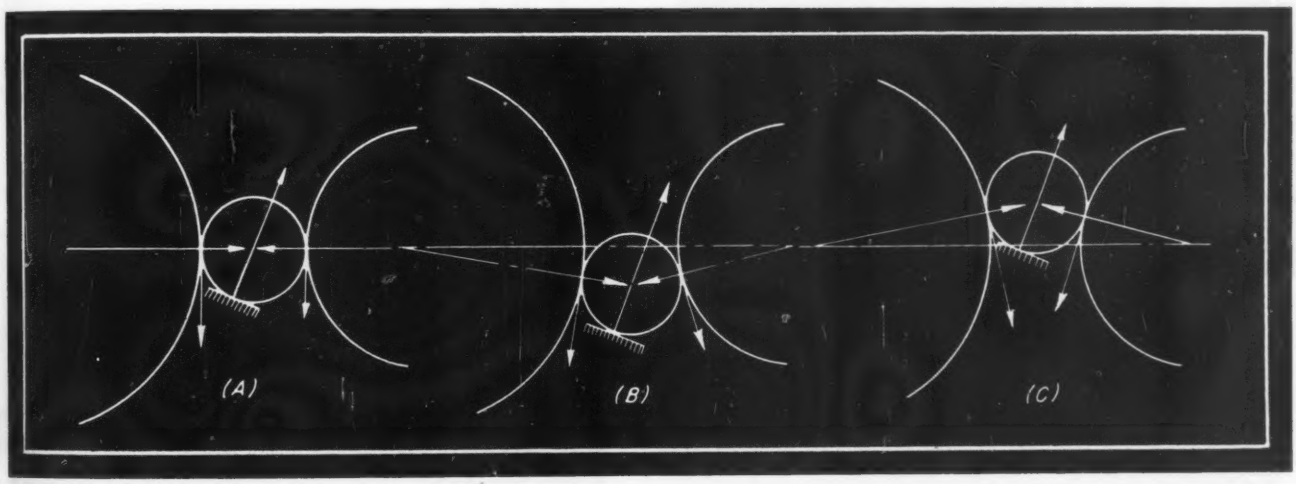


Fig. 1—Top—Regulating wheel controls speed of work and provides support against pressure from grinding wheel

Fig. 2—Above—Location of work rest determines position of work with respect to line of centers of wheels

IN THE production of precision parts for war and peace, centerless grinding has played a significant role. In addition to effecting substantial savings in the time and cost required to produce certain types of parts in large quantities, the process offers other advantages which should be taken into consideration by designers. For example, due to the rigid support of the work during the grinding cut, comparatively heavy but accurate cuts can be taken, even on easily distorted pieces. Again, because the largest possible circle is generated, less stock need be allowed for removal. Sizing, too, can be more accurate because the regulating wheel is fed a distance equal to the reduction in diameter of the work, instead of only half that distance as in the case of feeding tools to work supported on fixed centers.

Considering the importance and unique characteristics of the centerless grinding process, published information on the subject is somewhat scanty and widely scattered. It is the purpose of this article, therefore, to unify and augment the current knowledge concerning the theory of centerless grinding. It is hoped that the discussion will fill a definite need in making this information available.

Basic Elements: Because of the mechanical simplicity of the centerless grinder, the functions and basic principles are easily understood in their rudimentary form and are here briefly reviewed. Basic elements consist of the stationary grinding wheel, the regulating wheel or feed wheel mounted on a separate slide, and the work rest or blade located between the two wheels and supporting the work, *Fig.* 1. The speed of the grinding wheel corresponds to a cutting speed of from 5000 to 6000 feet per minute. The regulating wheel speed is much slower and ranges from 40 to 900 feet per minute. In this system the grinding wheel, in effect, is driving and the regulating wheel is driven, but with its speed controlled. The regulating wheel is mounted in such a fashion that it can be tilted relative to the axis of the grinding wheel, viewing it in the vertical plane, while in the horizontal plane it

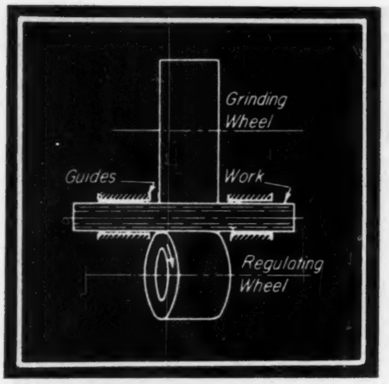
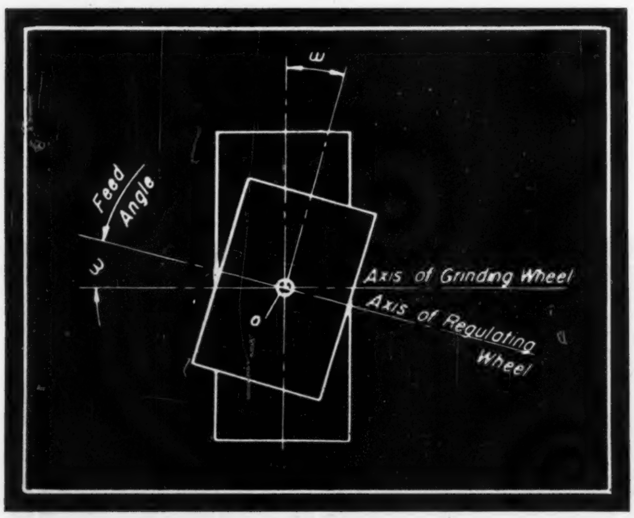


Fig. 3—Left—Linear traverse of work is obtained by tilting the axis of the regulating wheel

Fig. 4 — Below — Illustrates definition of feed angle, which determines rate of linear traverse



remains parallel to the grinding-wheel axis. As the name implies, the regulating wheel serves to regulate and control the cutting process; it controls the speed of the work in its rotary as well as its feeding motion. The work rest, or work blade, guides the work past the grinding wheel, while impelled by the regulating wheel. The diameter of the work which will be obtained after grinding depends on the positions of the grinding wheel, regulating wheel and work blade relative to each other.

Roundness of Work: Three positions of the work are commonly distinguished:

In the first, the work is placed between the wheels so that its center is in line with the center-to-center axis of the wheels, *Fig. 2A*. This position does not lend itself to fast rounding-up action, since the contact points are exactly opposite and a cavity or protuberance on the work results in a series of synchronous shocks.

Increasing the Straightening Effect

In the second, the work may be placed below the center-to-center axis and thus be confined and wedged between the wheels and blade, *Fig 2B*. In this case the pressure components on blade and regulating wheel are greatly increased and contribute to an effective straightening-out action of work of sufficiently small diameter. Rounding-up action is also more marked in this case compared with the first position. Shattering or whipping which occurs when work is not straight is thereby effectively eliminated.

In the third, the work may be placed above the center-to-center axis, *Fig. 2C*, and thereby lessen the pressure on the regulating wheel to a considerable degree and on the blade to a somewhat lesser extent. The contact points are not opposite and the direction of shocks tends to become tangential to the regulating wheel with decreasing included angle formed by center of work and the contact points. The cutting pressure is lower at concave spots and higher at convex spots, a tendency which grows with increasing peripheral speed and inertia force of work. Softer wheels, which have higher friction coefficients, signify lower pressure components, reduced shock and enhanced rounding-up action, as will a lower rate of feeding motion.

Linear Traverse or Feeding Motion: As mentioned previously, the feeding motion is obtained by tilting the regulating wheel. Assuming that there is no slippage between work and regulating wheel and that the intersection point O of the two axes, forming the feed angle ω, *Figs.* 3 and 4 is located in the middle of the regulating wheel, then the linear traverse F in inches per minute will be

$$F = V_r \sin \omega \qquad (1)$$

where V_r is the peripheral velocity of the regulating wheel in inches per minute. Hence the feed rate, being a function of the peripheral velocity V_r of the regulating wheel and the feed-angle ω, can be varied by changing one or both of these factors.

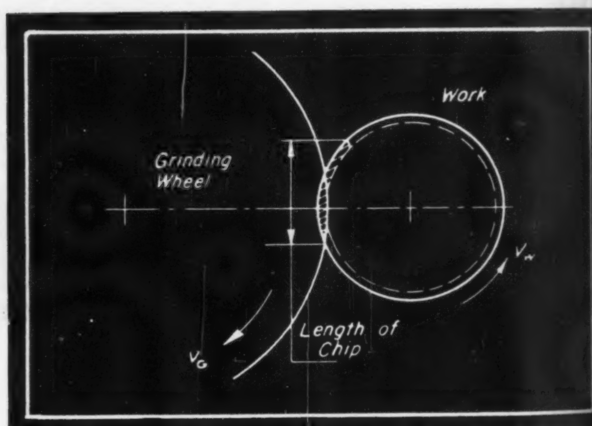


Fig. 5—For a particular grinding wheel speed, length of "chip" per unit time is a function of work speed

Stock Removal: Capacity to remove metal depends in the main on the available power, the suitability of the grinding wheel and the frictional resistance between work and regulating wheel. When T = depth of cut in inches, V_w = peripheral velocity of work in inches per minute, and F_o = feed per revolution of work ($F_o = F/n_w$ where n_w = revolutions per minute of work), then the volume Q of metal removed in cubic inches per minute is

$$Q = TF_oV_w \qquad (2)$$

The length of chip removed per unit of time is

$$V_g - V_w \qquad (3)$$

where V_g is the peripheral velocity of the grinding wheel

Fig. 5. Considering the extremes of the cutting process, it will be evident that the maximum length of chip will occur when the velocity of work $V_w = 0$, the wheel velocity V_g being considered constant. The length of chip will become zero when $V_w = V_g$. Inasmuch as the length of chip is a function of V_w, evidently the most efficient grinding depends upon the correct relationship of work velocity to grinding wheel speed, when stock removal is the primary consideration. The correct relative velocity of work and of grinding wheel is a matter of practical experience and depends on the qualities of the work and the grinding wheel and on the kind of surface finish desired. Discussion of these factors is beyond the scope of this article. From Equations 2 and 3 the cross section of the chip is obtained:

$$A = \frac{TF_o V_w}{V_g - V_w} \qquad (4)$$

When the depth of cut, T, the stock removal, Q, and the diameter of work d are known, the linear traverse F can be expressed thus:

$$F = \frac{Q}{d\pi T} \qquad (5)$$

The angle of inclination of the regulating wheel, i. e., feed

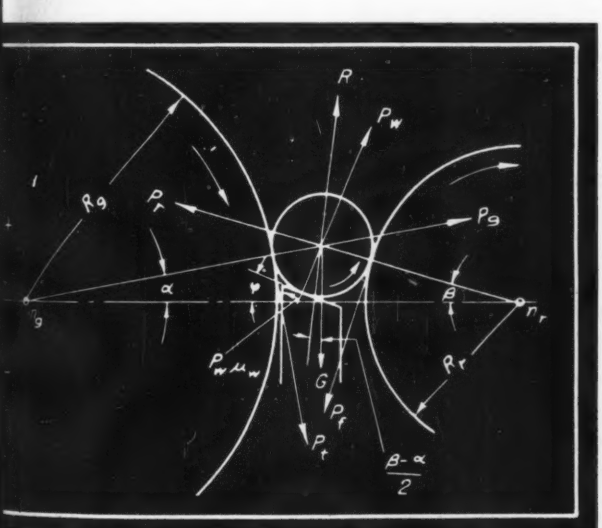


Fig. 6—When forces on the work are in equilibrium, the resultant R will be zero

angle ω, is obtained from the equation

$$\sin \omega = \frac{F}{D\pi n_r} = \frac{Q}{10DTdn_r} \qquad (6)$$

where D = diameter of regulating wheel and n_r = revolutions per minute of regulating wheel.

Concurrent Forces at Wheels: In calculating the forces at the wheels, the following notation will be employed:

P_t = Tangential cutting pressure
P_g = Contact pressure between work and grinding wheel
P_r = Contact pressure between work and regulating wheel
P_f = Tangential pressure on regulating wheel
P_w = Back pressure on work rest
R_g = Radius of grinding wheel
R_r = Radius of regulating wheel
G = Weight of work
μ_r = Coefficient of friction between regulating wheel and work*
μ_w = Coefficient of friction between work and rest†
r = Radius of work
n = Revolutions per minute
ϕ = Inclination of top of work rest
N = Horsepower
α, β = Directional angles
η = Mechanical efficiency

*Values depend on the cross section of the chip and the hardness of the wheel, and range from .20 to .65, according to Schwerd and Kurrein.
†Values may vary from .05 to .1.

Maximum cutting pressure is obtained when utilizing fully the available horsepower at the grinding wheel. When n_g is in revolutions per minute and R_g is in feet then

$$P_t = \frac{N \times 33000 \times \eta}{n_g \times 2\pi \times R_g} \text{ pounds} \qquad (7)$$

Forces acting on the work are shown in *Fig* 6, where

$$P_r \mu_r = P_f$$

Summing the tangential forces on the work it is evident that

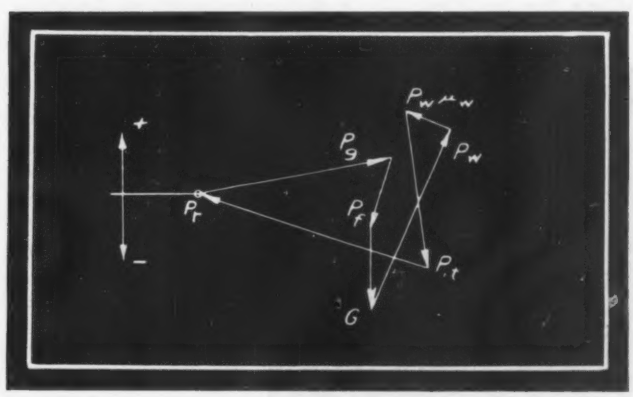


Fig. 7 — Above — Shows vector summation of forces acting on the work when in equilibrium

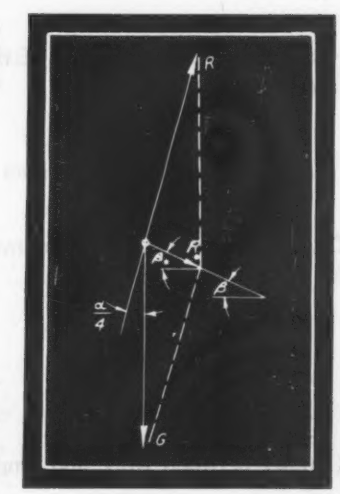


Fig. 8—Right—Contact of work and work rest will be maintained if angle β_o is equal to or greater than β

$$P_f = P_t - P_w\mu_w$$

In *Fig.* 7 is shown the vector summation of the forces on the work. For these forces to be in equilibrium ($R=0$)

$$P_g \sin\alpha - P_f \cos\beta - G + P_w \cos\phi + P_w\mu_w \sin\phi$$
$$-P_t \cos\alpha + P_r \sin\beta = 0 \quad (8)$$

If the work is placed too high above the center-to-center axis of the wheels, i.e., if the angles α and β are too great, a lifting and possible detachment of work from the blade or work rest will ensue. At the moment of detachment

$$P_w = 0$$

$$P_t = P_f \text{ and}$$

$$P_r = P_g$$

if it is assumed that the resultant, R, forms with the perpendicular the angle $(\beta-\alpha)/2$ and the weight of the work is disregarded. Further, if $(R_g+r)/(R_r+r)$ is assumed equal to 1.5 then $\beta \approx 1.5\alpha$ and Equation 8 can be expressed approximately as follows, when α and β are small,

$$2P_t\left(\frac{\sin 1.25\alpha}{\mu_r} - \cos 1.25\alpha\right) = \pm R \quad (9)$$

When the resultant, R, of the components of forces is

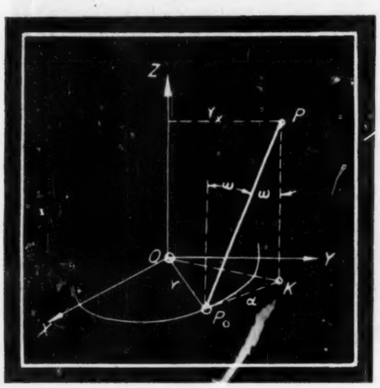


Fig. 9 — Left — Profile of truing wheel generated by rotating straight line PP_o about the axis OZ is exactly correct for work diameter zero

positive and the weight G, of the work is the concurrent force, *Fig.* 8, then

$$G = R\cos\frac{\alpha}{4} + \tan\beta_o R \sin\frac{\alpha}{4}$$

Dividing by $R\sin\alpha/4$, the following expression is obtained for β_o

$$\tan\beta_o = \frac{G}{R\sin\frac{\alpha}{4}} - \cot\frac{\alpha}{4} \quad (10)$$

Contact between work and work rest will be maintained when $\beta_o \geqq \beta$ and detachment ensues when $\beta_o < \beta$. The pressure R_o on the regulating wheel is

$$R_o = \sqrt{G^2 + R^2 - 2GR\cos\frac{\alpha}{4}} \quad (11)$$

Rectilinear Truing: When the work moves past the grinding wheel, impelled by the tilted regulating wheel, it is imperative that contact between work, grinding and regulating wheels be maintained over the entire width of the opposing wheels, in order to insure perfect straightness of work. This is accomplished approximately by selecting a truing angle of the regulating wheel which approaches as closely as possible the feed angle of the work relative to the axis of the regulating wheel.

Transposing the regulating wheel in an x-y-z system, *Fig.* 9, in which the axis of the regulating wheel is the z-axis and the intersection point O of both axes is located in the x-y plane, then the truing diamond traverses a path PP_o. A simultaneous rotation of the regulating wheel then generates the needed hyperboloid of the latter. Referring to *Fig.* 9, $OP_o = r$ is the throat radius of the hyperboloid; ω = truing angle (or feed angle); P is any point on the path of the diamond, r_x its corresponding radius and PK its corresponding z-ordinate. P_oK is the tangent at point P_o, hence

$$r_z^2 = [OK]^2 = r^2 + a^2$$

where $a = z \tan\omega$, from which

$$r_z^2 = r^2 + z^2\tan^2\omega \quad (12)$$

Since for every point P the equation

$$x^2 + y^2 = r_z^2$$

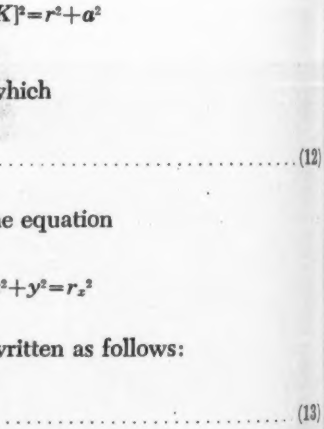
must be valid, it can be written as follows:

$$x^2 + y^2 - r^2 - z^2\tan^2\omega = 0 \quad (13)$$

which is in fact the equation of the hyperboloid of one nappe. The hyperboloid of the regulating wheel thus obtained is a function of the truing angle ω and is theoretically correct for zero-diameter work only.

Curvilinear Truing: It may be recognized by careful study of the foregoing that with increasing feed angle and

Fig. 10—Right—Truing wheel for cylindrical work piece is generated by revolving cylinder about axis OZ



growing diameter of work, the faculty of the hyperboloid to insure uniform contact of work over the entire width of the regulating wheel will be progressively impaired. The precise hyperboloid which meets the prime condition of uniform contact for any given diameter of work and feed angle is discussed in the following:

It is assumed that a precise hyperboloid has been gen-

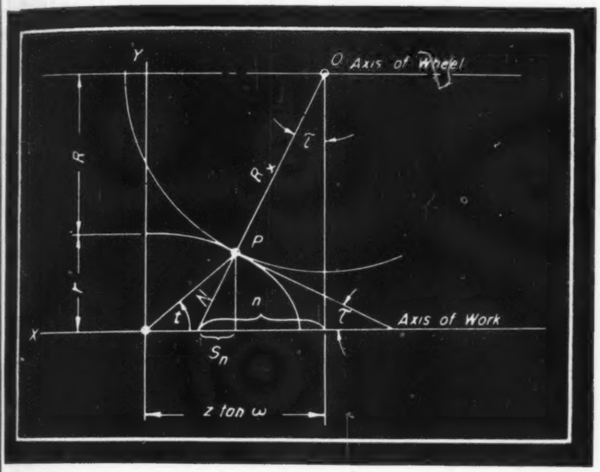


Fig. 11—Above—Diagram is used in deriving equations for the profile of the regulating wheel shown in Fig. 10

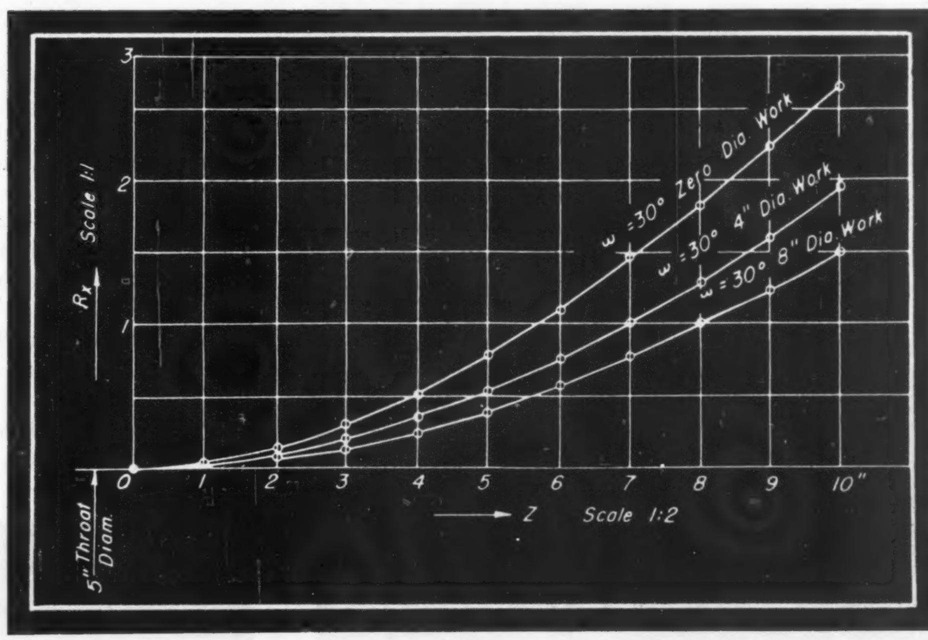


Fig. 12—Right—Ordinates represent increase of radius over throat radius for distances z along axis of regulating wheel

erated by revolving a perfectly straight piece of work around the regulating wheel. Let the feed-angle ω be the angle of inclination, *Fig.* 10. Let work and wheel be projected into an ordinate system, so that the throat of the wheel coincides with the x-y plane and the axis of the wheel with the z-axis. A cross section laid parallel to the x-y plane reveals a contact point, P, at which the elliptical cross section of the work touches the circular cross section of the wheel. The elliptical cross section of the work is a function of the feed angle ω, *Fig.* 11, and the major axis of the ellipse then is

$$\frac{r}{\cos\omega}$$

where r = radius of work. The parametric equations of the ellipse can then be written thus

$$x=\frac{r}{\cos\omega}\cos t \text{ and}$$

$$y=r\sin t$$

Taking the first derivative and multiplying, the tangent at point P is

$$\frac{dy}{dx}=-\cos\omega\cot t=\tan\tau$$

The subnormal then is

$$S_n=y\frac{dy}{dx}=-r\cos\omega\cos t$$

and the normal

$$N=\sqrt{S_n^2+y^2}=r\sqrt{\cos^2\omega\cos^2 t+\sin^2 t}$$

Similarly, when $R+r=D$, the distance between the axes, the dimension n (*Fig.* 11) is

$$n=D\frac{dy}{dx}$$

and

$$R_x+N=\sqrt{n^2+D^2}$$

Hence

$$R_x=D\sqrt{1+\cos^2\omega\cot^2 t}-r\sqrt{\cos^2\omega\cos^2 t+\sin^2 t}\;\ldots\ldots\ldots\ldots(14)$$

Also, according to *Fig.* 11,

$$z \tan \omega = n + x - S_n$$

$$z \tan \omega = D \cos \omega \cot t + \frac{r \cos t}{\cos \omega} - r \cos \omega \cos t$$

$$z = \frac{D \cos^2 \omega \cot t}{\sin \omega} + r \cos t \sin \omega \quad \text{.................. (15)}$$

A transcendental equation of this order permits of no direct solution (D, r and ω are variables), therefore recourse is made to the method of successive approximation to solve Equations 14 and 15, with the assumption that $R = 5$, $r = 2$ and $\omega = 30°$ and choosing a linear division of z from 0 to 10. The results are tabulated in TABLE I.

Employing the calculated values of R_z from Equation 14 the exact hyperboloid of the regulating wheel can be plotted as shown in *Fig.* 12. In order to illustrate the divergencies resulting from a variable diameter of work, the additional graphs for zero diameter and 8-inch diameter work are shown. The intersection point O will move to the front of the regulating wheel when the work is placed above the center-to-center axis of wheels and conversely will recede to the rear of the regulating wheel when work is placed below the center-to-center axis of wheels.

TABLE I

Regulating Wheel Calculations

z Inches	$t°$	cot t	cos t	sin t	R_z Inches	r_z Inches	x Inches
0	90°	0	0	1	5.0000	5.00	0
1	85° 1′ 43″	.08698	.08666	.99624	5.0217	5.03	.377
2	80° 7′ 18″	.17414	.17155	.98507	5.0867	5.13	.758
3	75° 20′ 22″	.26161	.2531	.96744	5.1945	5.29	1.147
4	70° 44′ 2″	.34953	.32995	.94399	5.3411	5.51	1.547
5	66° 20′ 51″	.43798	.40189	.91599	5.5273	5.77	1.960
6	62° 12′ 36″	.5270	.46623	.88466	5.7495	6.08	2.387
7	58° 20′ 40″	.61667	.52489	.85122	6.0057	6.43	2.829
8	54° 44′ 33″	.70692	.57725	.81656	6.2927	6.81	3.286
9	51° 25′ 8″	.79775	.62363	.78172	6.6075	7.21	3.750
10	48° 21′ 35″	.88910	.66447	.74733	6.9482	7.64	4.239

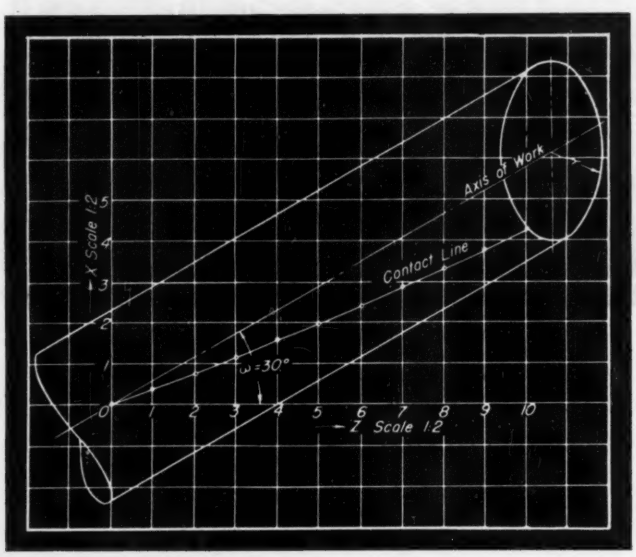


Fig. 13—Contact line between work and regulating wheel is a space curve, as shown on this projection

The hyperboloid generated by the method of rectilinear truing, which approaches the one plotted in *Fig.* 12 for 4-inch diameter work and a feed angle ω of 30 degrees, requires a truing angle of 25° 45′ 2″. The maximum discrepancy is .029-inch.

The contact line of work and wheel, a space curve, can be plotted in the x-y plane from

$$x = \frac{z \sin \omega - r \cos t}{\cos \omega} \quad \text{.................................. (16)}$$

The results are tabulated in the last column of TABLE I and shown in *Fig.* 13, which illustrates the contact line for the example given.

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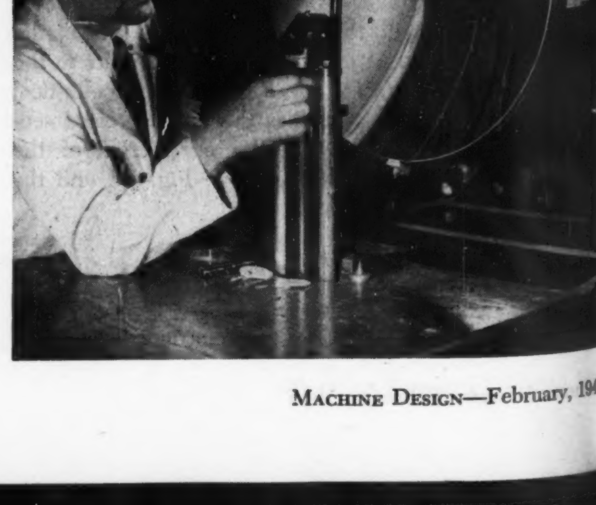
Eyes for the Navy

TO BE effective at 20 miles, Navy searchlights require reflectors shaped and finished to the degree of accuracy of an optical flat. Made of Stellite to resist corrosion or tarnishing from salt air, spray and fumes as well as damage or oxidation from the heat and possible sputtering of the electrodes, Chrysler-built 24-inch parabolic reflectors are formed on an electronically controlled machine and then Superfinished.

In the test illustrated below, a small light bulb is placed at the focal point and the reflected beam measured on a 24-inch pattern to prove its parallelism. It is said that a 2000-candlepower arc, which is the size generally used, when placed at the focal point would produce a 30,000,000-candlepower beam.



SPECIFYING DYNAMIC BALANCE

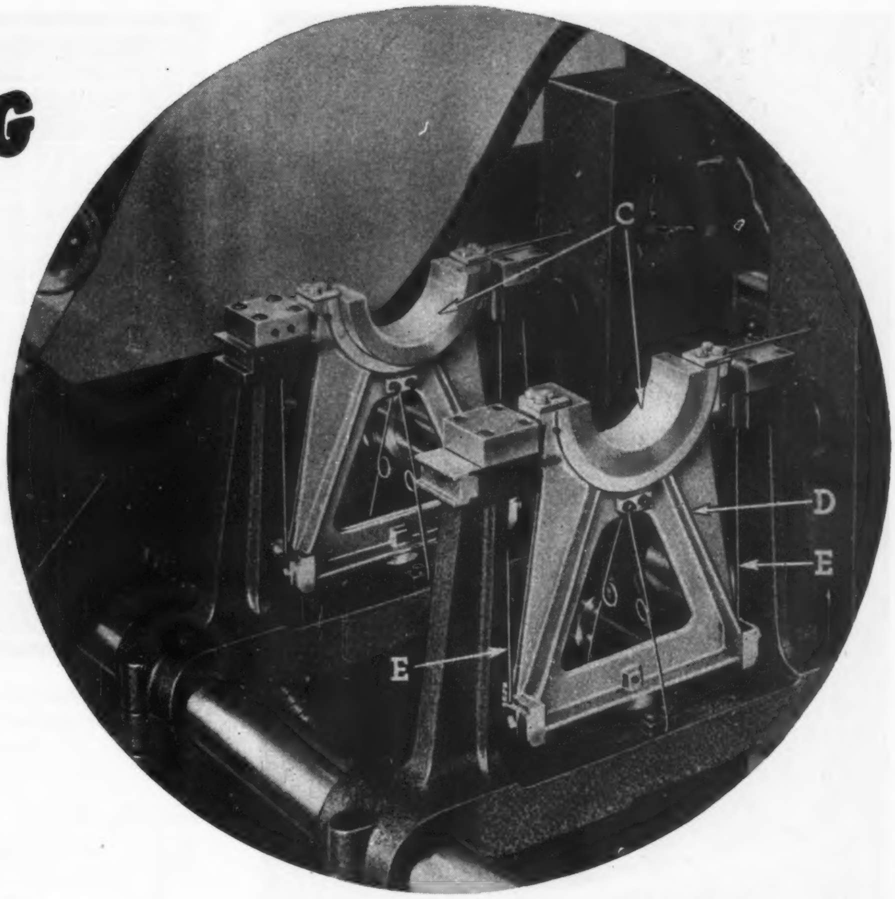


Fig. 29—Aluminum work supporting members on this balancing machine each weigh approximately 20 ounces, yet are capable of supporting a part weighing 300 pounds. Their light weight increases balancing accuracy

Part IV—Balancing Equipment

By W. I. Senger
Balancing Machine Division
Gisholt Machine Co.

DESIGNERS are occasionally required to requisition a balancing machine for laboratory purposes and also are consulted frequently by manufacturing personnel as to the type of balancing equipment which should be used in production to give the specified accuracy of balance. Unfortunately, recommendations are not always given with the same care that is used in establishing the tolerances for balance. Yet the manufacturing personnel should have the engineer's advice so that the ultimate product can be produced economically to desired balancing tolerances.

It is the purpose of this article to establish certain features which must be present in balancing equipment if it is to perform its function properly. These features involve the following requirements:

1. Work piece supports should be as light as practicable
2. Moment of inertia of work piece supports should be as small as possible
3. Amount and position of unbalance in two planes should be measured direct
4. Correction should be indicated in simple units
5. Measurement should not be made at or near critical speeds
6. Special foundations for machine should not

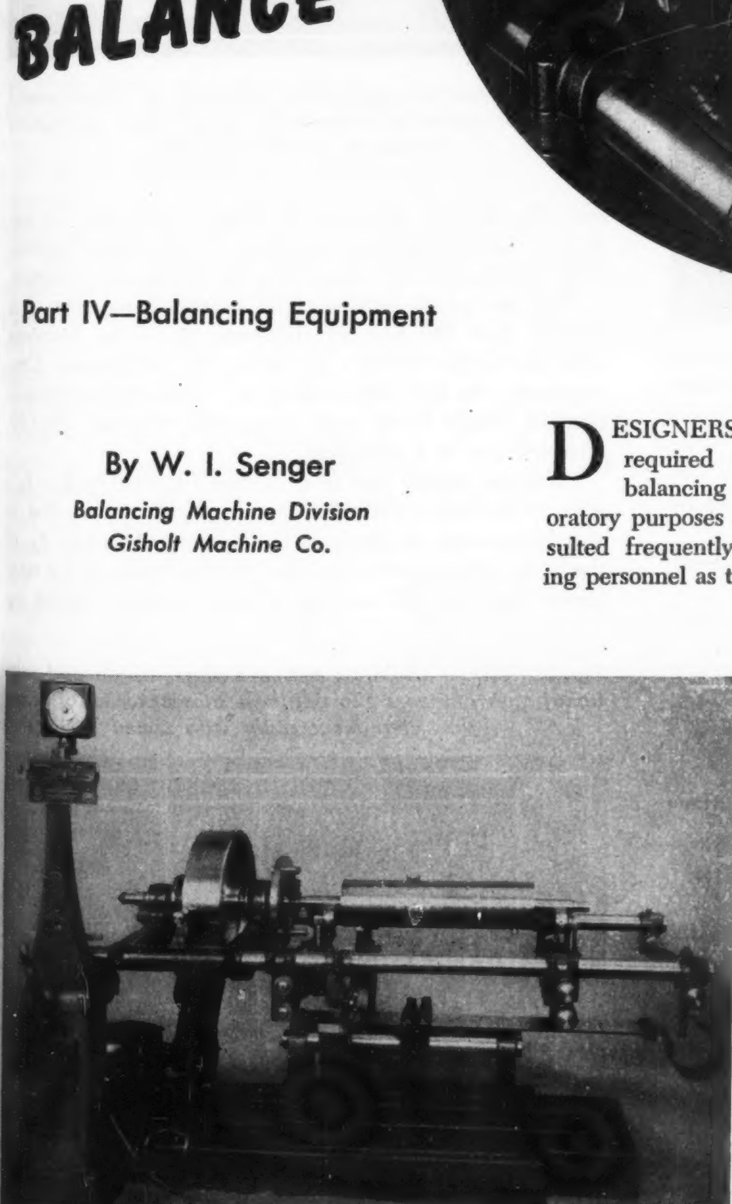


Fig. 30—Tubular frame for supporting the wprk in this machine has excessive mass and inestia, prohibiting accurate balancing

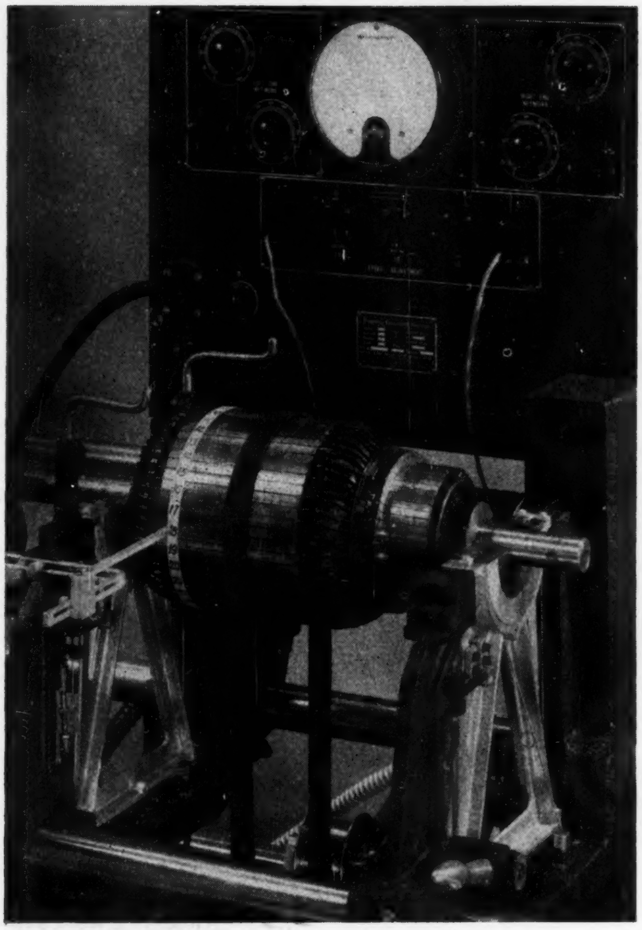


Fig. 31—This armature is carried by light weight aluminum supports which reduce to a minimum the parasitic weight and inertia on the accuracy of balance

be required to exclude extraneous vibrations

7. Large and accurate amplification of vibration should be incorporated in the design of machine
8. Machine should be capable of indicating unbalance readings with work piece rotating
9. Machine should be capable of balancing large or small number of parts quickly
10. Work piece should be supported freely during balancing operation
11. Plain bearing for work piece supports should be used except for special cases
12. When high accuracy of static balance is required, machine should be capable of measuring separately static and dynamic unbalance.

Many of these requirements are closely associated with the theoretical analysis made in Part I of this series (M. D., Nov., 1944). At that time it was determined that the displacement of the bearing of a rotating body, due to unbalance, could be determined from the approximation given in Equation 10:

$$p=\frac{wr}{W}+\frac{wrhJ}{g(I_X-I_Z)}\text{ Approximately} \quad \ldots\ldots\ldots\ldots\ldots (10)$$

As a balancing machine must provide some kind of support for the work piece, and because this support must have mass and inertia, it is evident that the characteristics of the supporting structure must have a considerable effect on the magnitude of the bearing displacement. Therefore, the ultimate accuracy to which a part may be balanced is affected by these supports. It is bearing displacement which must be reduced by the balancing operation.

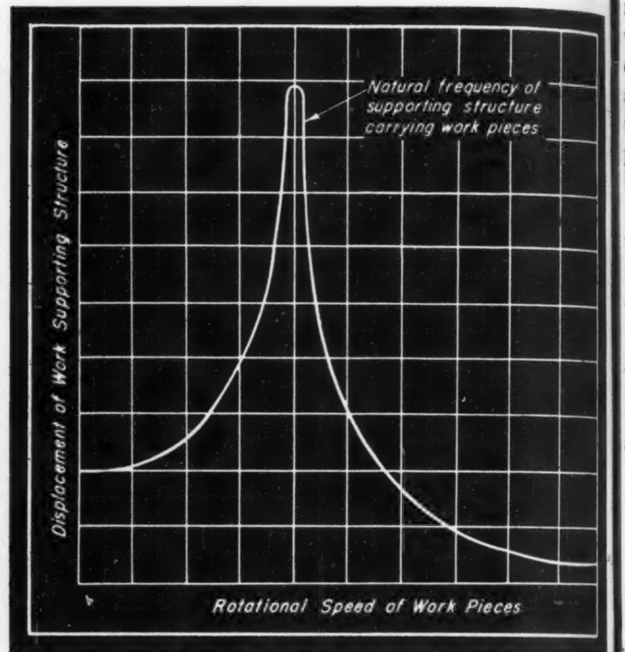
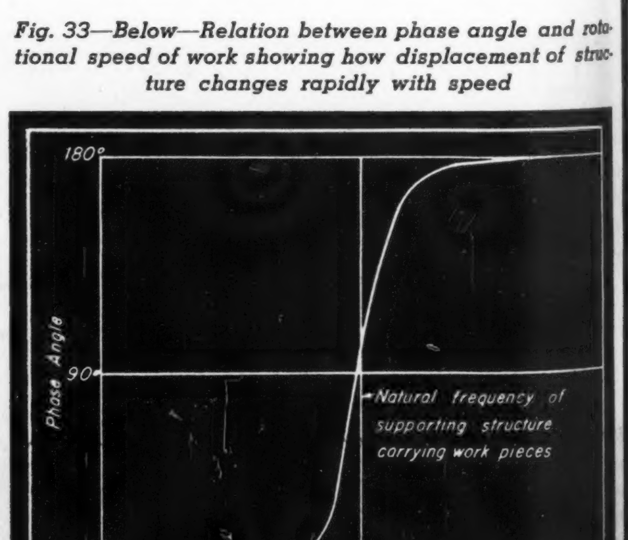


Fig. 32—Effect of supporting structure on displacement when work piece is rotated at a speed near the natural frequency of the structure

From the wr/W portion of the foregoing equation, it is evident that the bearing displacement varies inversely with the weight which is moved by the unbalance. Consequently, the first requirement of a balancing machine is that the weight of the work supporting structure, *Fig.* 29, must be kept to a minimum.

From the second part of Equation 10, $wrhJ/g(I_X-I_Z)$, it is to be noted that the bearing displacement due to unbalance varies inversely as the moment of inertia, I_X, of the body with respect to an axis, perpendicular to the rotational axis. As the bearings of most rotating bodies are

Fig. 33—Below—Relation between phase angle and rotational speed of work showing how displacement of structure changes rapidly with speed



near the ends of the body, any work supporting structure which supports the body at the bearing points must increase the value of I_X. The second requirement of a balancing machine therefore is: The moment of inertia of the balancing machine structure which supports the work piece and which must vibrate with the work piece should be as small as possible.

These two requirements for a balancing machine are responsible for the discontinuance of the use of lathe-bed frames as supporting structures for work pieces to be balanced. Even the pivoted frame machine of *Fig.* 30 adds too much mass and too much inertia to the work piece to permit of accurate balancing. The work supports of the modern balancing machine are as light as is consistent with the weight of the part which they must carry, *Fig* 31. They are generally light fabricated members.

Should Measure Unbalance Direct

Another requirement of a balancing machine is: A balancing machine should be capable of directly measuring and locating the corrections for balance to be applied in any two transverse planes without involved computation and without trial and error methods. Equipment which measures the amount of bearing displacement of the work piece without providing a means whereby these displacements may be converted into direct readings of required corrections, is not effective because the operator obtains balance by trial and error methods. An operator using a trial and error device will soon establish the balancing tolerance at that value which will give him a maximum possible income without producing too many parts which will be rejected at final inspection. Such an arrangement does not promote quality workmanship.

By reference to *Fig.* 7 (M. D., Nov., Page 104), it is evident that each of the bearings is displaced by the unbalance w in one of the planes of correction. This is indicated by the displacement of axis Z''-Z'' from the rotational axis Z-Z. Similarly, an unbalance on the other end of the work piece (in the other plane of correction) will cause displacements of both bearings. How then, can bearing displacements produced by the combined effects of unbalance in the two correction planes be expected to indicate directly the amount of correction to apply to the work piece? The separation of unbalance effects in the two planes of correction can be made by means of a pivoted frame balancing machine of the type shown in *Fig.* 30. This separation can also be made by means of the electrical network of the machine of *Fig.* 31.

Machines of the type shown in *Fig.* 30 use compensating weights to reduce the vibration of the machine frame to zero. Conversion of the compensating weight indication into corrections to be applied can only be accomplished by mathematics. Such an operation does not properly belong in manufacture. By means of voltage dividers, this mathematical operation is eliminated in the machine of *Fig.* 31. Therefore, the fourth requirement of balancing equipment closely associated with the above is: The balancing machine should indicate the amount of correction to be applied in units that are easily understood by the operator.

As has been mentioned previously, the average mechanic does not understand the engineering terms of ounce-inches or ounce-inch-inches. He can understand units such as thousandths of an inch of drill depth, inches of length of wire solder and the like. It was for this reason that Part III of this series of articles recommended that balancing tolerances be written in these easily understood units. If the balancing specifications are in such terms, the equipment used for balancing should be capable of reading in like terms.

Fifth among the tabulated requirements is: The balancing machine should not measure unbalance with the work piece running at or near the critical speed of the vibrating structure. *Fig.* 32 shows that the displacement of the work supporting structure will be large if the work is rotated at the natural frequency of the supporting structure. However, small speed variations make for large variations in amplitude with corresponding loss of balancing accuracy. Further, *Fig.* 33 shows that the phase angle between the unbalance and the displacement of the vibratory structure changes rapidly with small changes in speed. Obviously, a balancing machine, which attempts to measure and locate unbalance in a work piece while op-

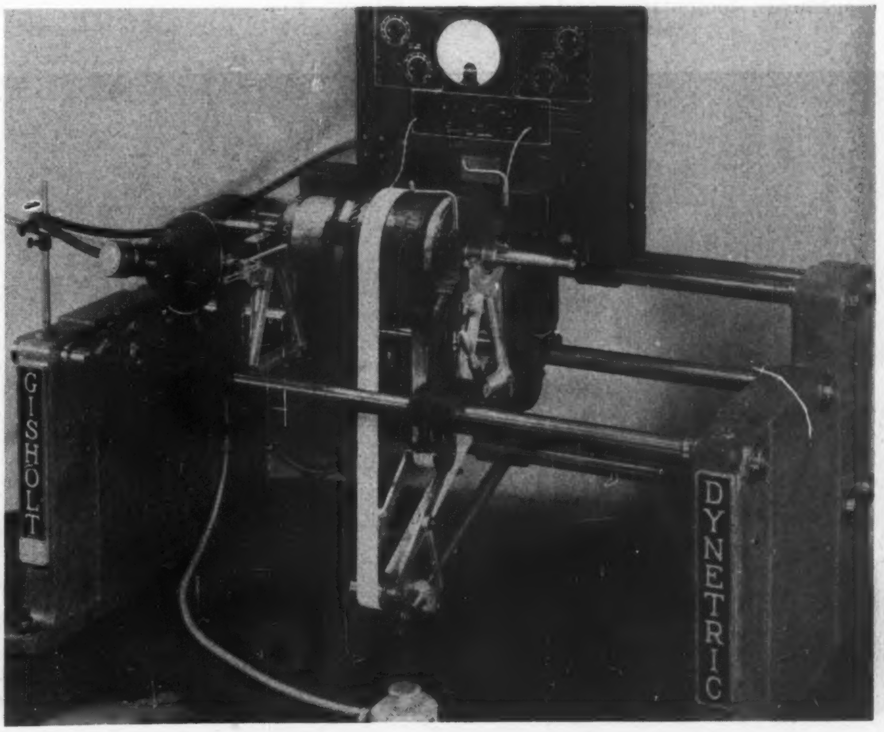


Fig. 34 — Right — Seismically mounted work-support structure and seismically mounted electromagnetic pickups of machine, together with electrical filtering in the amplifier cabinet, effectively eliminate floor vibrations without using a special foundation

erating at or near the critical speed of the supporting structure, cannot be expected to produce continually at high accuracy when slight speed variations (often as little as 1/100 of one per cent) cause large variations in indication. Therefore, an effective balancing device should have a supporting structure with a natural frequency not greater than 1/3 of the running speed of the work piece so that both phase angle and displacement are constant for reasonable speed variations. This will make for direct rapid production to tolerances established by the designer.

Sixth requirement is: The balancing machine should be of such design as will permit it to be placed anywhere in the shop without the requirement of a special foundation. A balancing machine should only indicate vibrations due to unbalance effects. Vibrations coming to the machine through the shop floor due to trucking, the operation of adjacent machine tools and motors should not appear as a part of the unbalance indication. Special foundations, which are required with some types of balancing equipment, are not always effective in eliminating these unwanted indications and such foundations make difficult the rearrangement of production lines.

By providing seismically mounted work supporting structures and by the use of mechanical and electrical filters in the machine, it is possible to build a practical unbalance indicating device which will not be affected by external vibrations, *Fig.* 34.

Requires High Sensitivity for Accuracy

Means for large and accurate amplification of the vibration should be incorporated in the balancing machine. This seventh requirement indicates that an extremely sensitive amplifying device must be used if balancing accuracy is to be obtained. The minute vibrations of the work piece in the supporting structure should give clear and distinct indications. Therefore, mechanical devices for the purposes of amplification are not desirable. Every mechanical unit must involve friction if there is motion. This friction is a variable which is dependent on manual adjustments, temperature and many other things. Further, mechanical devices must involve inertia effects which will definitely decrease accuracy.

Optical devices are more effective and are generally based on the principles of the oscillograph. However, to get great amplification by the optical means of the oscillograph, the indicating spot must increase in size at the same rate as the displacement of the spot is increased. Thus this means of amplification cannot effectively give great increase in readability.

The most effective means of amplification is by electronics. If proper care is exercised in the design of the electronic equipment, it is possible to get large amplification without losses and undesirable effects. However, the use of any make-and-break contacts in the electronic circuit must be avoided as such contacts require a displacement of the work before contact can be made. This displacement represents the accuracy to which balancing can be done. Further, make-and-break contacts will corrode and wear so as to vary the displacement required to make contact.

Other desirable features of balancing equipment which should receive consideration are of a less technical nature. They are tabulated earlier as requirements 8, 9, 10, 11, and 12 and are discussed briefly in the following:

Measuring and locating unbalance in both correction planes should be possible without stopping the machine. If readings of amount and angular location of unbalance can be taken for both correction planes without stopping the work piece, the time for balancing is considerably reduced.

The balancing machine should be suitable for quickly balancing parts in quantities and sizes as required by production. If small quantities of a part are to be balanced, the set-up time should be as short as possible. When parts are to be balanced in large quantities, semiautomatic unbalance measuring and correcting equipment should be considered, *Fig.* 35.

Work pieces should be supported freely in the balancing machine during the balancing operation. If the work piece or its supporting structure is restrained on one end

(*Concluded on Page* 196)

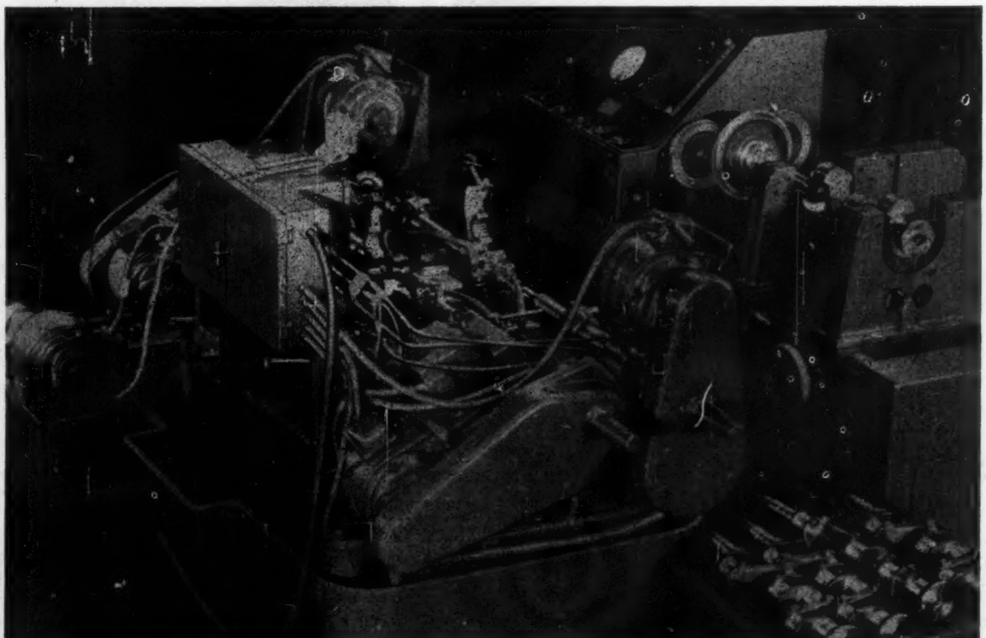


Fig. 35—Unbalance measuring and correction drilling machine provides a means whereby the amount of correction at each of two points in each of two radial planes in a crankshaft is measured and then removed. The unbalance measurements automatically set the depth to which each of the four correction drill spindles will enter the work, thus providing high production without a requirement for any guess or computation by the operator

MACHINE *Editorial* DESIGN

Can Design Be Accelerated?

TWO PHASES of the war situation, somewhat related, have been given added emphasis during the past few months and have brought new responsibilities to designers of machines. One is the lack of manpower which, though an old story, has never since the beginning of the war been as vital as at present. The other is the constant need for refinements in design of war equipment that are found desirable after the initial design has been completed.

Much might be done in both cases. With the increased schedule of war production for 1945 to around 65 billion dollars and the possibility that this high level will continue unless Germany surrenders abruptly, even more consideration will have to be given to completing the development of all types of production machinery that might effect greater output and a saving in manpower. It may even be possible to rush to completion some of the "postwar" developments in production machines sooner than had been anticipated before the setback in the Ardennes region and the consequent change in national thinking. Obviously it would take some time to put such machines into production lines, but anything that can be done by designers toward that end should be pushed to the limit.

Some figures on manhours that are illuminating were recently issued by the Aircraft War Production Council. Whereas a typical bomber, for instance, requires an average of about 140,000 engineering manhours for initial design, more than 1,600,000 are needed after delivery of the first machine in improving the design to meet the ever-changing conditions of war and production.

Such a situation is not new in design work but is more apt to arise frequently in wartime than in peace because of factors that are in some instances beyond the control of the designer. It is even more essential during war, therefore, that designers should utilize to the utmost their ingenuity and foresightedness in developing their machines to a point that a minimum number of changes will be necessary. Vital manhours may thus be saved.

L. E. Jermy

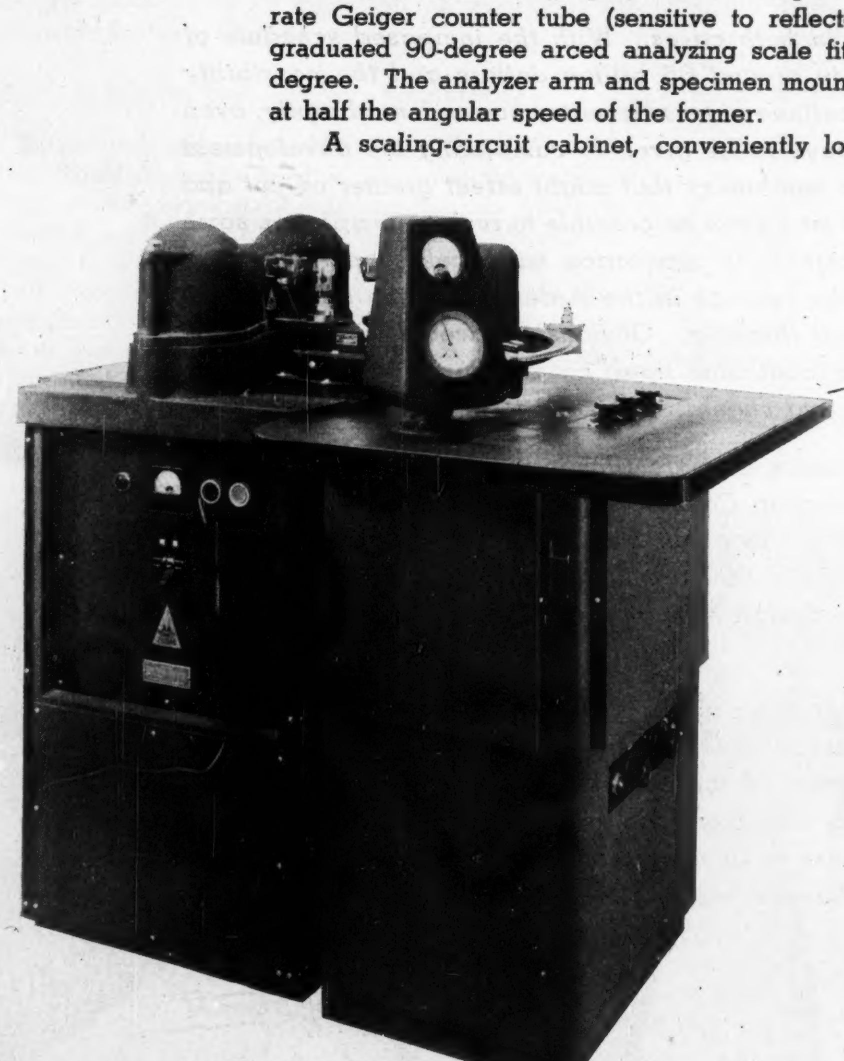
Outstanding Designs

X-Ray Spectrometer

X-Ray generator of this machine which provides an accurate method for measuring distribution and intensities of X-ray reflections employs an air-cooled X-ray tube mounted in a special rayproof housing surmounting a reinforced metal cabinet. This cabinet encloses a high-tension transformer, shockproof cables, cooling fan and, in addition, incorporates a control panel and machined horizontal table for mounting a goniometer. A main switch (circuit breaker) and a push-button-type high-tension control are utilized, and circuit conditions are revealed by a milliammeter and pilot light. Generator components are serviced easily by opening either of two side access panels. A built-in stabilizer eliminates drift resulting from line voltage variations.

The spectrometer proper, which incorporates a specially filled high-counting-rate Geiger counter tube (sensitive to reflected X-radiation) is provided with a graduated 90-degree arced analyzing scale fitted with a vernier reading to .01-degree. The analyzer arm and specimen mount are geared so that the latter turns at half the angular speed of the former.

A scaling-circuit cabinet, conveniently located in front of the operator and provided with a desk-type top, incorporates an electronic pulse amplifier, a scaling unit and a pulse inverter and limiter. These serve to condition pulses from the Geiger counter for operation of an average-frequency radiation meter and an electro mechanical counter employed for precise recording of reflected radiation intensity. The cabinet contains a Geiger counter power supply unit specially designed to provide a stabilized voltage output. Voltage controls for the Geiger counter are located on the lower front panel. The table top contains scaling-circuit controls and a momentary-contact switch for establishing a standard time base for observation. The machine is manufactured by North American Philips Company Incorporated.



Air Conditioner

Heart of this new air conditioner manufactured by American Coils Co. is an enclosed coil vapor compartment in which a relatively low temperature and vapor pressure is maintained. A fan draws the moisture laden air from the conditioned area and circulates it around the coil vapor compartment. Excess moisture flows through a series of openings into the compartment where it is condensed by the coil and drains out the bottom of the enclosure during each defrost cycle. The flow of vapor is caused by the difference in vapor pressure in the air as compared to the relatively low pressure maintained in the coil vapor compartment. A small portion of the air is drawn into the enclosure with the vapor and is cooled. This provides the necessary reduction in dry bulb temperature to compensate for heat gain in the conditioned area. The cool, dehumidified air is discharged directly into the conditioned area.

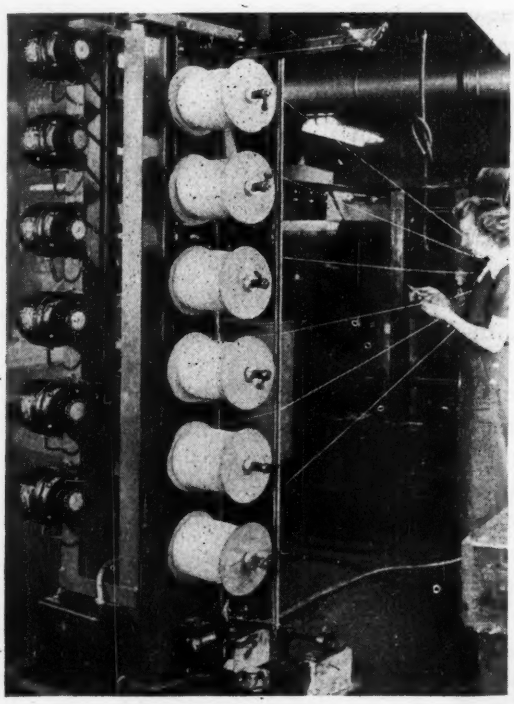
Coil employed is of the extended fin type, constructed of copper tubes with individual serrated aluminum fins. A series of quiet-operating, direct-connected, propellor-type fans are mounted in the top part of the cabinet. Inlet openings are provided through which fresh air may be supplied for proper ventilation.

During winter operation and in extremely dry climates it is necessary to add moisture to the air. Humidifier employed consists of an immersion-type strip heater located in the drain pan, the overflow water in which is arranged so the water will always cover the heater. The unit is completely automatic. A temperature control is provided for maintaining desired dry bulb temperature and a humidistat is connected so the unit will either add or remove moisture to maintain the proper relative humidity. A main switch with pilot light places the conditioner in operation. Also, a humidity switch and a cooling switch are provided, each with pilot light, permitting operation of the controls individually or together. A separate condensing unit is employed to provide refrigeration to the coil surface.

(New machines listed on Page 208)

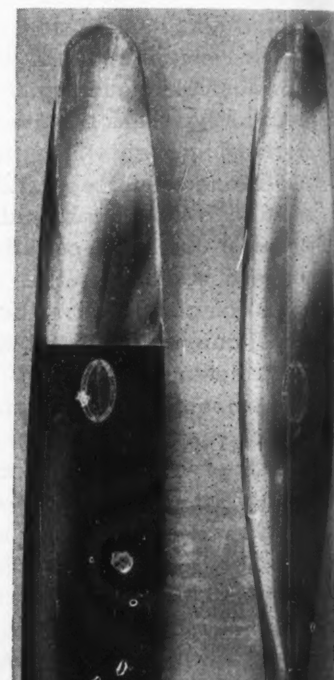
Applications

of Engineering Parts, Materials and Processes



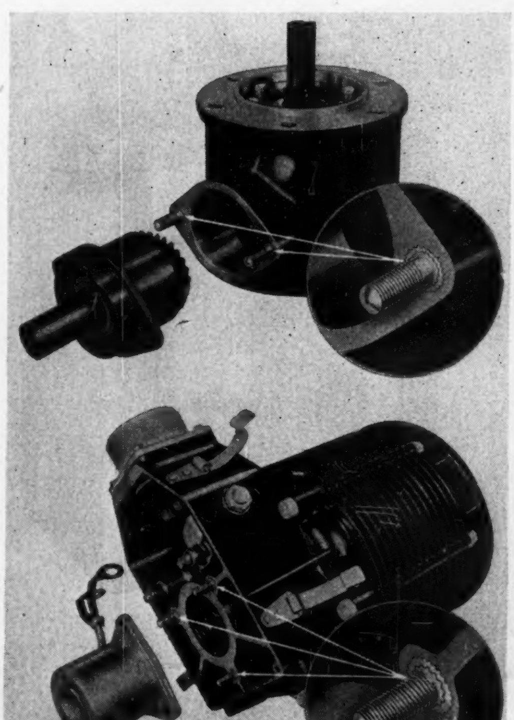
Controlling Winding Tension

CONTROLLED tension in winding small-sized plastic rod and tubing on spools is furnished by the Ohio Electric measured-torque motors shown on the winding machine at left. The uniform tension eliminates size variations, wastage, and other troubles encountered when friction clutches were used in an attempt to secure a steady pull. Three interchangeable resistors are provided in the power line, enabling a predetermined torque to be established according to the size of material being wound, which may be from .025-inch to .100-inch.



Propeller Blade Fairing

IMPROVED aerodynamic performance and lower engine temperatures result from the addition of fairings to airplane propellers. The changed shape is illustrated by the two blades shown at right, which are for a P-51 (Mustang) fighter. Made of Cell-Tite, a cellular rubber material, the fairings are practically impervious to water and weather, possess high resistance to chemical attack, and weigh only 4 to 6 pounds per blade.



Securing Blind Studs

TO SOLVE the problem of fastening to a blind hole and locking a stud so that vibration will not loosen the screw, Rosan fastening units are used in the Jahco engine starter housing and landing gear motor shown at left. After the stud is screwed into position the locking ring, which is serrated both inside and out, is pressed or driven into a counterbore. The inner teeth engage the teeth of a serrated collar on the stud while the outer teeth broach the wall of the counterbore. The unit can be removed by a simple shallow drilling operation without disturbing the parent metal.

Molded Plastics— General Properties and Uses

By J. H. DuBois
General Electric Co.

IN THE tables presented on Pages 172, 173 and 174, are given the general properties of and uses for plastic materials suitable for molding purposes. Materials are identified primarily by type of resin, and also by filler used, if any. Supplementing these tables, the listing of tradenames and manufacturers on this page will aid in the identification of specific materials.

Information in this Data Sheet is based on the author's book "Plastics", published by American Technical Society.

Plastics Tradenames and Producers

Type of Plastic & Tradename	Manufacturer
Phenolic	
Bakelite	Bakelite Corp., New York
Durez	Durez Plastics & Chemicals Inc., N. Tonawanda, N. Y.
Durite	Durite Plastics, Philadelphia
Heresite	Heresite & Chemical Co., Manitowoc, Wis.
Indur	Reilly Tar & Chemical Corp., New York
Makalot	Makalot Corp., Boston
Neillite	Watertown Mfg. Co., Watertown, Conn.
Resinox	Monsanto Chemical Co., Springfield, Mass.
Textolite	General Electric Co., Pittsfield, Mass.
Phenolic-aniline	
Cibanite	Ciba Co. Inc., New York
Dilectene	Continental-Diamond Fibre Co., Newark, Del.
Urea	
Bakelite Urea	Bakelite Corp., New York
Beetle	American Cyanamid Co., New York
Plaskon	Plaskon Division, Libbey-Owens-Ford Glass Co., Toledo, O.
Melamine	
Catalin Melamine	Catalin Corp., New York
Melmac	American Cyanamid Co., New York
Plaskon Melamine	Plaskon Co. Inc., Toledo
Cellulose-acetate	
Bakelite C. A., Class I	Bakelite Corp., New York
Cellulose Acetate	Hercules Powder Co., Wilmington, Del.
Fibestos	Monsanto Chemical Co., Springfield, Mass.
Lumarith	Celanese Celluloid Corp., New York
Macite	Manufacturers Chemical Corp., Berkeley Heights, N. J.
Monsanto C. A.	Monsanto Chemical Co., Springfield, Mass.
Nixonite	Nixon Nitration Works, Nixon, N. J.
Plastacele	E. I. du Pont de Nemours & Co. Inc., Arlington, N. J.
Tenite I	Tennessee Eastman Corp., Kingsport, Tenn.
Cellulose-acetate-butyrate	
Bakelite C. A., Class II	Bakelite Corp., New York
Hercose C	Hercules Powder Co., Wilmington, Del.
Tenite II	Tennessee Eastman Corp., Kingsport, Tenn.
Ethyl cellulose	
Ethocel	The Dow Chemical Co., Midland, Mich.
Ethofoil	The Dow Chemical Co., Midland, Mich.
Hercules Ethylcellulose	Hercules Powder Co., Wilmington, Del.
Lumarith E. C.	Celanese Celluloid Corp., New York
Nixon Ethyl Cellulose	Nixon Nitration Works, Nixon, N. J.
Polystyrene	
Bakelite Polystyrene	Bakelite Corp., New York
Loalin	Catalin Corp., New York
Lustron	Monsanto Chemical Co., Springfield, Mass.
Styron	The Dow Chemical Co., Midland, Mich.
Vinylidene chloride	
Saran	The Dow Chemical Co., Midland, Mich.
Methyl methacrylate	
Acryloid	Resinous Products & Chemical Co., Philadelphia
Acryloid	Rohm & Haas Co. Inc., Philadelphia
Crystalite	Rohm & Haas Co. Inc., Philadelphia
Lucite	E. I. du Pont de Nemours & Co. Inc., Wilmington, Del.
Plexiglas	Rohm & Haas Co. Inc., Philadelphia
Primals	Rohm & Haas Co. Inc., Philadelphia
Rhoplexes	Rohm & Haas Co. Inc., Philadelphia
Nylon	
Nylon	E. I. du Pont de Nemours & Co. Inc., Arlington, N. J.
Copolymer vinyl acetate and vinyl chloride	
Vinylite V (Vinyon)	Carbide & Carbon Chemical Corp., New York
Cold-molded plastics	
Aico	American Insulator Corp., New Freedom, Pa.
Alphide	Standard Plastics Corp., Jersey City, N. J
Amerine	American Insulator Corp., New Freedom, Pa.
Coltstone	Colt's Patent Fire Arms Mfg. Co., Hartford, Conn.
Ebrok	The Richardson Co., Melrose Park, Ill.
Cummon	Garfield Mfg. Co., Garfield, N. J.
Hemit	Garfield Mfg. Co., Garfield, N. J.
Molex	Molex Products Co., Chicago
Okon	American Hard Rubber Co., New York
Rosite	Rostone Corp., Lafayette, Ind.
Textolite—Cold Molded	General Electric Co., Pittsfield, Mass.
Thermoplax	Cutler-Hammer Inc., Milwaukee
Mycalex	
G. E. Mycalex	General Electric Co., Pittsfield, Mass.
Mycalex	Mycalex Corp. of America, Clifton, N. J.
Mykroy	Electronics Mechanics Co., Clifton, N. J.

Engineering Data Sheet—General Properties and Uses for Molded Plastics

Type	Filler	Colors	Applications	Notch Impact (Ft. lb. per In.)	Flexural (psi)	Tensile (psi)	Water Absorption % 48 Hours	Heat Resistance Continuous °F.	Dielectric Strength Volts per Mil Step by Step Test in Oil 1/8 in. Specimen 25° C.	Dielectric Strength 100° C.	Specific Gravity	Shrinkage In. per In. *	Bulk Factor †
Phenolic	None	Amber-green, Ruby, Turquoise, Tortoise Shell	Milking machine parts and sterilizable equipment also used for hard synthetic jewels. Thermosetting	.34-.44	10,000-14,000	7000-8000	.1	248	250-300	70-100	1.28	.009-.011	2.25
Phenolic	Woodflour	All Colors except pastels	For general purpose molding applications. Thermosetting	.30-.40	9000-12,000	6000-8000	.5-1.0	248	300-450	60-125	1.33-1.45	.006-.009	3
Phenolic	Woodflour	Natural and Black	For general purpose high-dielectric applications. Thermosetting	.28	10,000	7000-8000	.8-1.0	248	350-500	100-200	1.33-1.35	.007-.008	3
Phenolic	Woodflour	Natural and Black	Parts requiring good water resistance and minimum odor. Thermosetting.	.30-.35	9000-11,000	5000-7000	.5-.8	248	250	50	1.40	.008	3
Phenolic	Woodflour & Graphite	Gun Metal	For bearings, cams, slides, caster wheels, etc. requiring reduced friction. Thermosetting	.30	8000-9000	6000	.8-1.0	248	....	....	1.42	.007-.008	3
Phenolic	Asbestos & Woodflour	Most colors except pastels	For heater plugs and insulating pieces requiring good heat resistance. Thermosetting	.30	9500-11,000	6000	.2-.5	392	250-400	50-80	1.67-1.80	.005	3
Phenolic	Short Fibre Asbestos	Black & Brown	For parts requiring better heat resistance and for low power arc resistance. Thermosetting	.30	9000-10,000	6000	.01-.1	428	250-400	50-80	1.80-1.90	.003-.005	3
Phenolic	Long Fibre Asbestos	Black & Brown	Best phenolic for heat resistance, low moisture absorption, low coefficient of expansion and maximum dimensional stability. Thermosetting	.36-.40	9000-9500	5000-6000	.01-.1	428	250-400	50-80	1.80	.003-.004	3
Phenolic	Asbestos & Graphite	Gun Metal	For bearings, slides, valves, cams, etc. requiring maximum heat-resistance and dimensional stability with good resistance to wear. Thermosetting	.28	8000-9000	6000	.01-.1	428	....	....	1.75	.003-.004	3
Phenolic	Asbestos	Natural & Brown	For high-heat and high-impact applications. Thermosetting	.50	10,000	6500	.3	428	125	50	1.80-1.85	.002-.003	6
Phenolic	Asbestos	Natural & Dark Tan	For high heat—low flame, high-impact applications. Thermosetting	3.40	10,000	6200	.8	392	70-100	50-70	1.60-1.70	.003-.004	5
Phenolic	Mica	Natural & Black	For electrical applications requiring improved heat and low-moisture absorption. Thermosetting	.30	8000	6000	.01-.05	428	300-500	150-300	1.88-1.92	.002-.004	2.5
Phenolic	Cotton Flock	Most dark colors	A general purpose molding material with improved impact resistance. Thermosetting	.42-.60	9500-12,000	7000-8500	.8-1.0	248	250-300	60-80	1.36-1.42	.003-.006	4
Phenolic	Cotton Flock	Black	Combines good water resistance, minimum odor and improved impact resistance. Thermosetting	.52	10,000	6500	.8-1.0	248	125	40-50	1.42	.004-.005	4
Phenolic	Fabric—Short Fibre	Natural, Black, Red, Brown	A medium-high impact material with good flow for complex sections. Thermosetting	1.00-1.80	10,000-12,000	6000-6500	1.0	248	200-250	50-80	1.38-1.42	.003-.004	5
Phenolic	Fabric — Medium Fibre	Black, Brown, Red	A high-impact material generally used for bulky sections. Thermosetting	3.00-3.50	10,000	6000-6500	1.0	248	200-250	50-80	1.38-1.42	.003-.004	8

**Shrinkage*. The values listed in the table give the amount of shrinkage in inches per inch under average conditions. Allowance must be made in the mold design to compensate for this shrinkage.

†*Bulk Factor*. Mold designs must allow sufficient space for loading the molding compound. The ratio of the volume of compound before molding to the volume of the molded piece is called the bulk factor.

*Shrinkage. The values listed in the table give the amount of shrinkage in inches per inch under average conditions. Allowance must be made in the mold design to compensate for this shrinkage.

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Engineering Data Sheet—General Properties and Uses for Molded Plastics

Type	Filler	Colors	Applications	Notch Impact (Ft. lb. per In.)	Flexural (psi)	Tensile (psi)	Water Absorption % 48 Hours	Heat Resistance Continuous ° F.	Dielectric Strength Volts per Mil Step by Step Test in Oil ⅛ in. Specimen		Specific Gravity	Shrinkage In. per In. *	Bulk Factor †
									25° C.	100° C.			
Phenolic	Chopped Cord	Black	Highest-impact phenolic material. Cannot be used for some complex sections. Thermosetting..............	5.0	11,000	6200	1.0	248	300	70	1.35	.003	8
Phenolic	Fabric & Graphite	Gun Metal	For cams, bearings, slides, etc. requiring high impact and reduced friction. Thermosetting....................	.70-.89	8000-9000	6000	.8-1.0	248	....	....	1.45	.003-.004	4
Phenolic	Cotton Flock and Graphite	Gun Metal	For cams, bearings, slides, etc. requiring medium-impact resistance and reduced friction. Thermosetting.....	.40	9500	6500	.8-1.0	248	....	....	1.40	.003-.004	4
Phenolic			Used for the shielding of X-rays......	.30	9500	6900	.5	248	....	....	....	.005-.006	3
Phenolic-aniline	Woodflour	Natural	Highest electrical properties with good arc resistance. Thermosetting......	.30	10,000	6000	1.25	248	300	300	1.34	.006-.008	3
Phenolic-aniline	Mineral	Natural	Radio or similar parts requiring low dielectric losses. Thermosetting. P.F. @ 1000 K.C.—.009..........	.38	9500	6500	.02	257	300-500	300-400	1.94	.004	2.5
Phenolic-aniline	Cotton Flock	Natural	Highest electrical properties with improved impact resistance. Thermosetting..........................	.46	10,000	6500	1.20	248	300	200-300	1.34	.006-.008	4
Urea	Cellulose	All colors including translucent and pastel shades	General purpose color work. Has good arc resistance. Used for lamp shades, packages, radio cabinets, etc. Thermosetting.........................	.30	11,000	8000	2.00	170	300	80	1.49	.008	3
Melamine	Cellulose	All colors including translucent and pastel shades	General purpose color work with improvedt emperature resistance. Good for dishes and buttons...........	.28	12,000	6000	1.7	210	230	250	1.50	.008	3
Melamine	Mineral and Cotton Flock	Gray	For electrical applications requiring improved arc resistance. Excellent for ignition parts. Thermosetting...	.44	8900	5000	.25	284	300	200	1.80	.006	2.5
Melamine	Fabric	Gray & Black	Combines good impact resistance with improved arc resistance. Thermosetting...........................	.90	10,000	7000	1.0	248	230	80	1.49	.003-.004	12
Cellulose-acetate		All Colors, transparent, translucent & opaque	General purpose injection molding material. Uses limited by low softening point and moisture absorption. Thermoplastic.....................	1.0-3.5	14,000	3000-8000	3.0	150	300	....	1.30	.002-.010	3
Cellulose-acetate Butyrate		All Colors, transparent, translucent & opaque	General purpose injection and extrusion material with better resistance to distortion under heat and humidity. Thermoplastic.....................	1.0-4.0	12,000	3300-8000	2.0	150	200	....	1.20	.002-.010	3
Ethyl cellulose		All Colors, transparent, translucent & opaque	Products requiring good strength at low temperatures, water resistance, toughness, weather resistance and dimensional stability. Some forms used as rubber substitutes. Thermoplastic.	.8-7.0	10,000	3000-8000	1.75	150	300	....	1.13	.002-.008	3

*Shrinkage. The values listed in the table give the amount of shrinkage in inches per inch under average conditions. Allowance must be made in the mold design to compensate for this shrinkage

†Bulk Factor. Mold designs must allow sufficient space for loading the molding compound. The ratio of the volume of compound before molding to the volume of the molded piece is called the bulk f ctor.

Engineering Data Sheet—General Properties and Uses for Molded Plastics

Type	Filler	Colors	Applications	Notch Impact (Ft. lb. per In.)	Flexural (psi)	Tensile (psi)	Water Absorption % 48 Hours	Heat Resistance Continuous ° F.	Dielectric Strength Volts per Mil Step by Step Test in Oil ⅛ in. Specimen		Specific Gravity	Shrinkage In. per In. *	Bulk Factor †
									25° C.	100° C.			
Polystyrene		All Colors, transparent, translucent & opaque	For parts requiring good electrical properties and resistance to chemicals. Has low gravity, zero moisture absorption and good stability. Thermoplastic	.4-1.0	14,000	4000-9000	0	150	500	....	1.07	.002-.006	2.5
Vinylidine chloride		Unlimited	Extruded for chemical and water resistant tubing. Injection molded for chemical equipment, plating racks and valve seats. Is used as wire insulation. Thermoplastic	2.0	14,000	6000	.01	160	300	....	1.68	.004-.012	2.5
Methyl methacrylate		All Colors, transparent, translucent & opaque	Excellent transparency and optical properties, low gravity, fair chemical resistance. Is used for lenses, decorative parts, nameplates, packages, etc. Thermoplastic	.2-.4	12,000	5000	.5	120	350	....	1.18	.002-.006	2.5
Nylon		Unlimited	Molding applications limited at the present time	.7	8500	10,000	1.0	150	300	....	1.10	....	2.5
Copolymer Vinyl chloride & vinyl acetate		All Colors, except a water white	Minimum cold flow at room temperature, good water and chemical resistance, good impact resistance and is non-inflammable. Some forms used as rubber substitute	.4-.8	10,000	8000	.1	130	375	....	1.34	.001	2.5
Copal	Asbestos	Red	Good electrical properties and arc resistance	.4	3000	....	.7	122	300	....	1.50	.003-.004	6
Cold mold—non-refractory		Black & Brown	Wiring device parts, cookware handles to withstand oven temperatures. Best cold mold for appearance	.4	4500	....	2.0	482	60	....	2.00	.015	2.5
Cold mold—refractory		Gray	For arc deflectors, rheostat bases and other parts requiring maximum heat and arc resistance	.6	5000	....	.05-15	1292	60	....	2.20	Nil	2.5
Synthetic hard rubber	Mineral	Red	For electrical and ignition parts requiring good arc resistance and good dielectric at elevated temperatures	.32	7000	4000	.08	175	370	370	1.77	.0195-.0225	2
Mycalex	Mineral	Gray	Radio and other high frequency electrical applications requiring maximum heat and arc resistance. P.F. @ 1000 K.C.—.0023	....	10,000	....	.0023	662	....	380	3.11	Nil	......
Mycalex	Mineral	Gray	General purpose electrical applications requiring low moisture absorption, high temperature and arc resistance P.F. @ 1000 K.C.—.0018	....	12,000	....	.001	482	....	325	3.70	Nil	......

**Shrinkage.* The values listed in the table give the amount of shrinkage in inches per inch under average conditions. Allowance must be made in the mold design to compensate for this shrinkage.

†*Bulk Factor.* Mold designs must allow sufficient space for loading the molding compound. The ratio of the volume of compound before molding to the volume of the molded piece is called the bulk factor.

MACHINE DESIGN'S MATERIALS WORK SHEET

FILING NUMBER
5.02

Stainless Steels

AISI Types 430 and 430F

AVAILABLE IN:

(430) Sheets, plates, strip, bars, wire, forging billets, tube rounds, welding electrodes and core wire, nails, screws, bolts, nuts, rivets, rods, tubing and cold-drawn shapes

(430F) Forging billets, hot-rolled and cold-finished bars, wire, screws, bolts, rivets, and polished shafting

ANALYSES:

Type	C	Mn	P	S	Si	Cr	Ni	Mo
(430)	.12 max	1 max	.03 max	.03 max	1 max	14 to 18	.6 max	......
(430F)	.12 max	1 max	.03 max	.07 min[1]	1 max	14 to 18	......	.6 max

[1]Or .07 per cent minimum of selenium.

PROPERTIES

ULTIMATE TENSILE STRENGTH*
(nominal, psi)

Sheet, annealed†	80,000
Strip, cold-rolled†	100,000
annealed†	80,000
Wire, cold-drawn 20 per cent†	90,000
40 per cent†	100,000
60 per cent†	110,000
annealed†	80,000
Plate, annealed†	80,000
Tubing, annealed†	80,000
Bars, cold-drawn 20 per cent†	92,000
annealed†	80,000
Forgings, annealed†	80,000

YIELD STRENGTH*
(.2% offset, psi)

Sheet, annealed	45- 55,000
Strip, cold-rolled	45-100,000
annealed	45- 55,000
Wire, cold-drawn	60-110,000
annealed	40- 60,000
Plate, annealed	40,000
Bars, cold-drawn	55-105,000
annealed	40- 55,000

CREEP STRENGTH*
(for life of 10,000 hrs. with 1% elongation)

Temperature	psi
1000 F	8,500
1100 F	5,000
1300 F	1,400

*Applies to both alloys.
†A.S.T.M. values.

MACHINE DESIGN is pleased to acknowledge the collaboration of the following companies in this presentation: The American Rolling Mill Co.; Carpenter Steel Co.; Republic Steel Corp.; Rustless Iron & Steel Corp.; U. S. Steel Corp.

REDUCTION IN AREA*
(per cent)

Sheet, annealed	55-40
Strip, cold-rolled	40-20
annealed	55-40
Wire, cold-drawn	70-45
annealed	75-55
Plate, annealed†	50
Tubing, annealed†	50
Bars, cold-drawn 20 per cent†	45
annealed†	50
Forgings, annealed†	50

ELONGATION IN 2 INCHES*
(nominal, per cent)

Sheet, annealed†	25
Strip, cold-rolled†	8
annealed†	25
Wire, cold-drawn 20 per cent†	13
40 per cent†	10
60 per cent†	8
annealed†	25
Plate, annealed†	25
Tubing, annealed†	25
Bars, cold-drawn 20 per cent†	15
annealed†	25
Forgings, annealed†	25

HARDNESS*

BRINELL (3000-kg load, 10-mm ball)

Sheet, annealed	145-185
Strip, cold-rolled	185-270
annealed	145-185
Plate, annealed	170
Bars, cold-drawn 20 per cent	190
annealed	170
Forgings, annealed	170

HARDNESS *(Cont'd.)*

ROCKWELL

Sheet, annealed		B80
Strip, cold-rolled		B98
annealed		B80
Wire, cold-drawn	20 per cent	B93
	40 per cent	B98
	60 per cent	C23
annealed		B82
Plate, annealed		B80
Tubing, annealed		B80
Bars, cold-drawn		B83-100
annealed		B71-91

PHYSICAL CONSTANTS

(for both alloys)

Melting Point (deg F)	2650-2700
Scale Resistance (max temp for continuous service, deg F)	1550
Specific Gravity	7.7
Weight (lb per cu in.)	.277
Modulus of Elasticity (psi)	29,000,000
Coef. of Thermal Expansion (per deg F)	
0 to 200 F	.0000058
0 to 600 F	.0000061
0 to 1000 F	.0000063
0 to 1500 F	.0000069
Thermal Conductivity (Btu/sq ft/hr/deg F/in.)	
At 200 F	156
1000 F	170
Specific Heat (Btu/deg F/lb) 0 to 200 F	.152
Electrical Resistivity	
(microhms per cu in.) at 70 F	23.5
Magnetic Permeability (in annealed state)	Ferromagnetic

CHARACTERISTICS

Type 430: A "ferritic chromium iron," this alloy is low in carbon and high in chromium. It is ductile, comparatively nonhardening and has mechanical properties about the same as those of high-grade medium carbon steel. Has high resistance to general corrosion and oxidation at high temperatures, offering oxidation resistance to 1550 degrees Fahr. In the form of cold-rolled strip and cold-drawn wire it is extremely ductile and lends itself readily to complicated press work. It can be spot welded, seam welded and stitch welded in thin sections, but does not have good welding characteristics in heavy sections where arc or flame welding must be employed.

The color of this alloy, when buffed, is similar to that of chromium plate. It offers good corrosion resistance to atmosphere, fresh water, foodstuffs, nitric acid, milk and dairy products, etc.

Type 430F: A "free machining" modification of Type 430. It contains a higher sulphur content and an addition of molybdenum. Has about the same mechanical and physical properties and corrosion resistance as 430 and, like 430, does not appreciably harden by heat treatment or cold work. Also, like 430, its impact resistance is comparatively low in notched sections, and where great toughness is required other types of stainless should be used.

APPLICATIONS

These alloys find wide usage in applications where a ductile, workable alloy of high corrosion resistance is desired. They are used extensively for parts and equipment such as: Tanks, soot blowers, press plates, screw machine products, oil burner parts, and automotive trim such as running board and body moldings, door handles, hub caps, finishing washers, radiator grilles, gas tank caps, etc. Similarly, it is used for trim on cameras, vending machines, electrical appliances, etc.

FABRICATION

MACHINABILITY:

Type 430, like other high-chromium steels, has a tendency to gall or seize under the high pressures incurred in machining. Cutting exerts tremendous pressure on the nose of the tool and the galling which results heats up the tool and reduces machining rates.

In spite of these characteristics, Type 430 can be machined without excessive difficulty if cutting tools have a steep top rake or lip angle and a smooth, stoned top surface. Usually, a good grade soluble cutting oil with a high sulphur content is helpful. Assuming bessemer screw stock to have a machinability rating of 100, Type 430 stainless has a machinability of about 50 to 60. As compared to other alloy steels, its machinability is approximately on a par with that of SAE 3140, 4140 and 6140.

Type 430F stainless is considerably easier to machine than Type 430 due primarily to the larger percentage of sulphur (or selenium) in its composition which reduces galling and seizing tendencies. On the basis of 100 for the machinability rating of bessemer screw stock, Type 430F stainless has a rating of about 85 to 90. It machines about as easily as SAE 1120.

BLANKING, PUNCHING AND SHEARING:

Generally speaking, of the two alloys covered by this Work Sheet, only Type 430 is produced in plates, sheets and strips. This alloy is about 50 per cent stronger, harder and tougher than soft mild steel and has a definite tendency to pick up or gall on press tools. Thus, the press employed must be more powerful than would be used for mild steel. In addition, tools wear faster and it is recommended that they be made from the best possible grades of wear-resisting tool steel. It is not advisable to attempt punching a hole which is smaller in diameter than the stock thickness. In blanking and punching the metal must be cut through its entire thickness. This is because it does not "break out" readily as do other materials. Die clearances are closer than for mild steel and cutting edges must be kept sharp, otherwise dragging will occur and result in burred edges.

DRAWING, FORMING AND SPINNING:

Drawing: More power and sturdier equipment is required for drawing Type 430 stainless than for ordinary steels. A drawing speed of about one-half that used for mild steels is rec-

PROPERTIES AT ELEVATED TEMPERATURES*

(based on short-time tests)

	Temperature (degrees Fahr.) 400	600	800	1000	1200	1400
Tensile Strength (psi)	67,000	63,000	56,000	36,000	19,000	7,500
Elongation in 2 Inches (per cent)	28	28	29	36	62	70
Reduction of Area (per cent)	76	75	75	84	97	99

ommended and pressure pads are adjusted to exert greater force on the blank to prevent wrinkling. Clearance between punch and draw die generally is about twice that used on ordinary steel or brass. Radius on the draw ring should be greater and the ring well polished. It is imperative that a good grade of drawing compound be used. Generally, these have an oil or animal-fat base and are highly sulphurized. Where a number of draws are required, the drawing compound is removed thoroughly and the parts annealed between operations. Average reduction per draw is approximately 25 to 30 per cent.

Forming: "Spring back" is figured to be almost twice that encountered when press-forming ordinary steel and usually a larger radius on the forming tools is recommended. The latter reduces work hardening. Dies should be highly polished and a good grade of lubricant employed.

Spinning: Because spinning work hardens materials more rapidly than do other operations, frequent annealing is necessary. Considerable power is required and Type 430 stainless has a tendency to wrinkle along the edges. This is overcome, however, by throwing a flange on the edge of the blank and working the center metal first. Roller-type tools create less friction than solid-nose types and therefore see more general use. Spindle speeds employed are about one-half those used for regular steel and a yellow or naphtha soap is used as a lubricant. Spinning destroys surface finish, thus gloss-surface stock should not be specified for spinning blanks.

DRILLING:

High-speed, "quick-spiral" drills are recommended and, if possible, should have heavier webs than standard types. A modified point angle, more blunt than for regular steels, works best and the web is ground thin at the point to relieve resistance and curtail cold working. Back clearance should not be excessive. For this operation, a sulphurized-oil lubricant is used.

FORGING:

Overheating of Type 430 is rigorously avoided as it causes grain growth with attendant loss in toughness and ductility. Heating is slow up to 1500 to 1600 degrees Fahr., followed by thorough soaking at this point. The metal then is brought up rapidly to forging temperature. Billets and large sections are started at 1900 to 2000 degrees Fahr. and finished between 1300 and 1400 degrees Fahr. Smaller sections are heated to 1700 to 1800 degrees Fahr. Working is rapid at the initial temperature and more gradual as the metal cools. Except in cases where considerable reduction must be effected, temperature is held as low as is consistent with workability, the finishing temperature in no case exceeding 1400 degrees Fahr. Generally, parts are annealed after forging to obtain maximum corrosion resistance.

Type 430F stainless is more sensitive to forging than Type 430 and is handled with considerable care to avoid splitting. "Forging Quality" should be specified when ordering.

WELDING:

Type 430 can be welded by acetylene torch, electric arc, electric resistance, and other commercial methods. It cannot be forge or hammer welded. Welds are not tough in this material because of the considerable grain growth which results from the high welding heat. For this reason Type 430 is not recommended for welded construction except for special high-temperature service. Type 430F tends to develop small checks or leaks when welded, thus is not recommended for welding except where tightness is not a factor.

BRAZING:

Rather tedious and not generally recommended. Due to the high temperature required—about 1750 degrees Fahr.—coarsening of the grain structure develops and results in reduction of toughness. If temperature is held too long or is too high, intergranular cracking may occur with the bronze filler rod penetrating along the grain boundaries.

SILVER SOLDERING:

Much preferred to welding or brazing because of the lower temperatures required and the strong joints produced. Special stainless-steel silver solders are employed having low melting points. A good flux is a mixture of borax or boric acid with sodium or potassium bifluoride.

SOLDERING:

Used primarily as a sealer with the strength of the joint dependent on lock-seam, lock-seam riveted or spot-welded construction. Good results are obtainable with special commercial fluxes using ordinary solder and following the same procedure employed with copper, tin, terne, etc. After soldering, acid is thoroughly removed with a 5 to 10 per cent solution of washing soda. If this is not done the metal will stain. Since the metal has low thermal conductivity, a large soldering iron is used to heat the metal thoroughly.

RESISTANCE TO CORROSION

Type 430 offers high resistance to atmosphere, fresh water, foodstuffs, nitric acid and milk and dairy products. It also is highly resistant to sulphur gases up to its maximum service temperature. To insure maximum resistance parts are "immunized" or "passivated." This consists of dipping the part in a cold 20 per cent solution of nitric acid for about 30 minutes or a warm (about 150 degrees Fahr.) 20 per cent nitric acid solution for about 10 minutes. A thin oxide film is thus developed which not only helps to combat corrosion but dissolves particles of foreign material which are picked up by the stainless from tools or polishing wheels.

GALVANIC CORROSION

When either of these alloys is placed in contact with other metals and wet with any liquid that will carry an electric current, galvanic corrosion will occur. Aluminum, zinc, cadmium and ordinary iron or steel all tend to protect stainless steel and the attack, if any, goes to the other metal. However, nickel, lead, copper, brass, graphite and silver throw the attack on the stainless and are themselves protected. An insulating lacquer can be used to hold dissimilar metals apart.

ANNEALING

These alloys cannot be hardened to any appreciable extent by quenching from high temperatures. They harden to about 250-275 brinell when rapidly cooled from 1800 to 1850 degrees Fahr. They tend to develop a coarse-grained structure if held for any prolonged period above 1650 degrees Fahr., and may become embrittled by such treatment. Accordingly, they normally are subjected only to annealing treatment consisting of heating to 1450-1550 degrees Fahr. for one to two hours followed by water quenching.

If a temperature of 1550 degrees Fahr. is not exceeded in heat treating Type 430, or 1450 degrees Fahr. in the case of Type 430F, they may be water-quenched after annealing. In

ANNEALING *(Cont'd.)*

general, cooling these alloys rapidly from annealing temperatures results in better impact properties.

In some special cases where Type 430 is subjected to severe cold-forming operations, as in cold heading, the following annealing cycle is recommended: Heat to 1500-1650 degrees Fahr. for two to three hours, cool slowly to 1000-1200 degrees Fahr. at a rate of 25-50 degrees Fahr. per hour, then air-cool to room temperature. However, this special treatment is not generally recommended for most applications because while it produces slightly lower hardness it also reduces the notch toughness of the material.

DATA ON STOCK FORMS

Sheet Finishes

No. 1—Hot-rolled, annealed and pickled.
No. 2D—Full finish (dull).
No. 2B—Full finish (bright cold-rolled).
No. 4—Standard polish, one or both sides.
No. 6—Standard polish, Tampico brushed, one or both sides.
No. 7—High luster finish.
No. 8—Mirror finish.

Their General Applications

No. 1: For parts which require no further finishing—for oxidation or scale resistance.

No. 2D: Similar to No. 1, except slightly better finish due to cold rolling. For deep-drawn articles which are polished subsequent to fabrication.

No. 2B: Slightly harder temper than No. 1 and No. 2D, hence should not be used for difficult deep drawing.

No. 4: For use where a polished finish is demanded. It is used for such equipment as dairy and ice cream tanks, etc.

No. 6: Tampico brushing of the No. 4 finish results in a satin finish with lower reflectivity than No. 4. For ornamentation where a brighter finish is undesirable.

No. 7: The buffing of No. 4 finish results in a sheet with a high degree of luster but in which some grit lines remain.

No. 8: The highest degree of polish commercially available. Grit lines and scratches removed. Suitable for press plates as used in the laminated paper and fibrous products industry.

REPRINTS

All Materials Work Sheets published in MACHINE DESIGN since the original presentation in October, 1943, to December of 1944, have been reprinted in loose-leaf form, with stiff covers. One reprint is being mailed out as a service to readers with each copy of this issue of MACHINE DESIGN. Additional reprints are available at the following prices:

Quantity	Price Per Copy
1	$1.00
2-9	.90
10-24	.80
25-49	.70
50 or more	.60

Orders should be sent to Readers Service Department, MACHINE DESIGN, Penton Bldg., Cleveland 13, O., and a 3% state tax included for those originating in Ohio.

Cold-Rolled Strip

A.S.T.M. THICKNESS TOLERANCES

Specified Thickness (inches)	Tolerance—Plus or Minus (inches): 3/16 to ½-inch wide excl.	½ to 1-inch wide excl.	1 to 1½ inch wide excl.	1½ to 3-inch wide excl.	3 to 6 inches wide	Over 6 to 9 in. wide	Over 9 to 12 in. wide	Over 12 to 16 in. wide	Over 16 to 20 in. wide	Over 20 to 23[illegible] in. wide
Under .006	.0005	.0005	.0005	.0005	.0005	.....	.....	.....	.....	.....
.006 to .009 incl.	.00075	.00075	.00075	.00075	.00075	.....	.....	.....	.....	.....
.010	.001	.001	.001	.001	.001	.001	.001	.001	.0015	.0015
.011	.001	.001	.001	.001	.001	.001	.001	.0015	.0015	.0015
.012	.001	.001	.001	.001	.001	.001	.0015	.0015	.0015	.0015
.013 to .014 incl.	.001	.001	.001	.001	.001	.0015	.0015	.0015	.002	.002
.015 to .016 incl.	.001	.001	.001	.001	.001	.0015	.0015	.0015	.002	.002
.017 to .019 incl.	.001	.001	.001	.001	.001	.0015	.0015	.002	.002	.002
.020 to .022 incl.	.001	.001	.001	.001	.0015	.002	.002	.002	.0025	.0025
.023 to .025 incl.	.001	.001	.001	.001	.0015	.002	.002	.002	.0025	.0025
.026 to .028 incl.	.001	.001	.0015	.0015	.0015	.002	.002	.002	.0025	.003
.029 to .031 incl.	.0015	.0015	.0015	.0015	.002	.0025	.0025	.0025	.003	.003
.032 to .034 incl.	.0015	.0015	.0015	.0015	.002	.0025	.0025	.0025	.003	.003
.035 to .039 incl.	.002	.002	.002	.002	.0025	.003	.003	.003	.003	.003
.040 to .049 incl.	.002	.002	.002	.002	.0025	.003	.003	.003	.004	.004
.050 to .068 incl.	.002	.002	.002	.002	.003	.003	.003	.003	.004	.004
.069 to .099 incl.	.002	.002	.002	.002	.003	.003	.003	.004	.004	.004
.100 to .160 incl.	.002	.002	.002	.002	.003	.004	.004	.004	.005	.005
.161 to .249 incl.	.002	.002	.003	.003	.004	.004	.004	.005	.006	.006

Note: Permissible variations in thickness are based on measurements taken ⅜-inch in from the edge on cold-rolled strip 1-inch or over in width and at any place on the strip on material less than 1-inch in width.

MATERIAL TRADENAMES

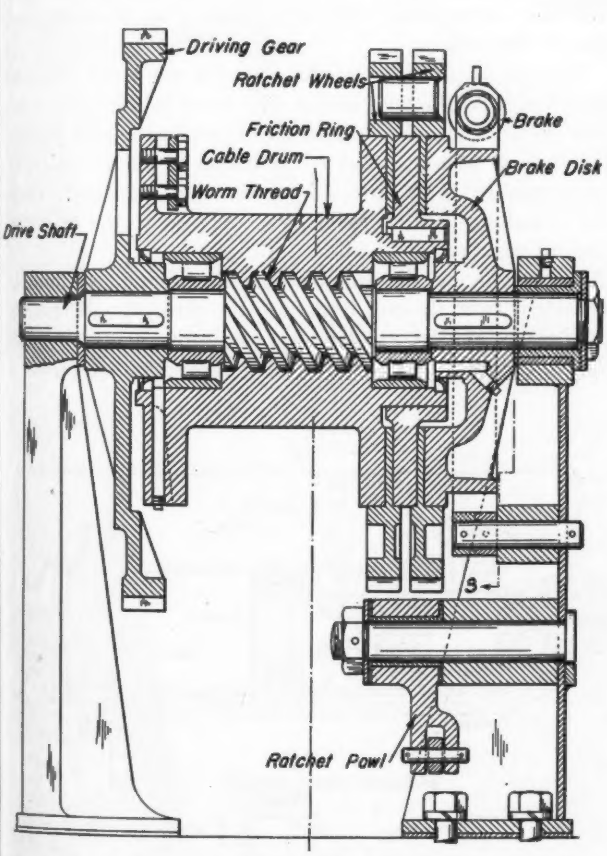
Producers	Type 430	Type 430F
Allegheny Ludlum Steel Corp.	Allegheny 17	Allegheny 17-EZ
American Rolling Mill Co.	Armco 17	
Bethlehem Steel Co.	Bethadur 430	Bethadur 431
Carpenter Steel Co.	Carpenter No. 6	Carpenter No. 6-FM
Crucible Steel Co. of America	Stainless Iron No. 17	....
Colonial Steel Co., Vanadium Alloys Steel Co.	Stainless "C-2"	....
Firth-Sterling Steel Co.	Type "M"	....
Jessop Steel Co.	Duro-Gloss C2	Duro-Gloss C2-FM
Latrobe Steel Co.	Lesco "M"	Lesco "LMF"
Midvale Steel Co.	Midvaloy 17-00	Midvaloy 17-00-Mo
Republic Steel Corp.	Enduro AA	Enduro AA-FM
Rustless Iron & Steel Corp.	Rustless 17	Rustless 17 FM
Universal Cyclops Steel Corp.	Uniloy 1809	Uniloy 1809-M
U. S. Steel Corp.	USS 17	....

Noteworthy Patents

Boom Hoist Is Self-Holding

An unusually compact boom hoist mechanism which embodies the desirable features of a worm-drive hoist and fits in with all the usual arrangements of such machinery is covered by patent 2,357,462 recently assigned to the Byers Machine Co. This hoist arrangement has been developed principally for use in medium-size power shovels or material-handling equipment with similar requirements.

As illustrated in the accompanying drawing, the hoist cable drum is mounted on the driving shaft to allow a relative action somewhat like that of a nut on a screw thread. The supporting roller bearings allow for axial shifting of the drum during relative movement between it and the drive shaft. The teeth of the two identical ratchet wheels are held in correct alignment by three studs permanently fastened to one wheel and engaging with fitted holes in the other. This provides for axial float of the two ratchets during operation, allowing for locking and unlocking of the friction rings.



This boom hoist mechanism features large bearing and holding areas with holding action entirely independent of any external braking mechanism

To hoist, the powering mechanism moves the driving gear in a counterclockwise direction when facing the brake end of the drum. Action of the worm thread in the cable drum as the hoisting action starts causes the drum to move to the right until the drum flange, friction ring, and ratchet wheels lock against the brake disk and rotate as a unit. The wheels ratchet freely during the hoisting process and the load can be stopped at any point by merely stopping the power to the driving gear. A brake is provided as a safety measure in case of failure in the drive arrangement. Either the brake or the train of driving gears in conjunction with the ratchet wheels will hold the load. Stopping the driving gear and brake disk does not in any way disturb the load on the cable or the frictional seizure of the system.

To pay out cable from the drum, the drive shaft must be moved in a clockwise direction. This, of course, produces a reverse action in the worm thread, causing the drum to shift to the left sufficiently to release the friction plate system. In this manner the cable is unwound by the load. Should the drum turn faster than the driven shaft by this means, the drum flange locks against the friction plates held by the pawl, checking the load descent momentarily until the driving shaft again releases the elements.

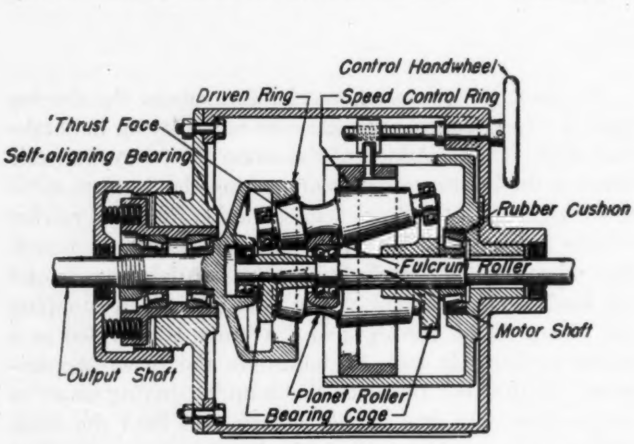
Variable-Speed Planetary Transmission

A variable-speed transmission of improved and simplified design is shown in the accompanying illustration. In addition to improved bearing life in the transmission, provision is made to compensate for the usual machining variations encountered in the manufacture of similar equipment. Automatically self-aligning planet rollers achieve the desired result. The design is outlined in patent 2,342,071 recently assigned to the Falk Corp.

In the transmission shown, the three symmetrically arranged planet rollers are uniformly inclined so as to place the contact line of each roller parallel to the axis of the main shafts. The inclined axis of each roller is retained in a radial plane by the parallel bearing cages attached to the driveshaft. The rollers thus are made to travel about the axis of the drive shaft and are free to rotate by virtue of the antifriction bearings at each end. These roller-support bearings float in radial slots in the bearing cages, providing self-aligning action in operation.

Supporting the planet rollers against the spring-imposed thrust of the driven ring is a fulcrum roller which also maintains the axial position of the planet rollers. Rotating freely upon an antifriction bearing, the fulcrum roller transmits pressure from the driven ring to the nonrotating speed-control ring. Thrust loading imposed by the coil springs may be varied by means of an adjustable end

cap to provide a magnitude of pressure between the rolling elements sufficient to prevent slip. By means of the rubber-cushioned main bearing, the fulcrum and planet roller assembly will automatically center and align with respect to the driven and speed control rings, creating uniform driving loads on all the elements. A self-aligning ball bearing at the opposite end of the motor driveshaft provides a pivot point for this aligning action as well as support for the shaft.



Floating planetary roller assembly of this variable-speed transmission is self-aligning to maintain uniform distribution of loads on the rings

Rotation of the motor shaft drives the planetary rollers through frictional engagment with the fixed control ring. Similar frictional engagement of the rollers with the driven ring produces a corresponding rotation governed by the planetary action of the elements. The rate and direction of rotation imparted is regulated by the axial adjustment of the control ring, the length of roller radius at the point of contact being the controlling factor.

A speed-control handwheel effects axial adjustment of the control ring by means of a simple rotating screw acting in a nonrotating nut. A vertical pin retains the ring against rotation and provides the necessary lateral movement. Contact faces on the control ring and on the driven ring are made slightly convex to reduce the effective area of contact with the rolling elements and assure optimum unit driving pressures.

Master Cylinder Has Controlled Operation

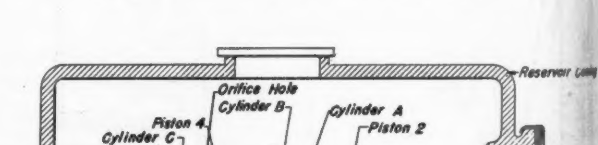
SMOOTH even development of pressure in a hydraulic brake system should be a feature totally independent of the operator. A compound master cylinder which provides transition from low pressure applied by an operator to high-pressure output for a brake system with controlled application is covered by patent 2,348,367 recently assigned to the Wagner Electric Corp. In addition, this efficient master cylinder avoids the use of compensating port holes and their deteriorating effect on piston-sealing cups which must pass over them in operation.

As shown in the illustration, main cylinder *A* and the attached assemblies are free to float within the limits of an annular groove in the casing which is engaged by a snap ring fitted to the cylinder. Piston 2 is normally held against a stop by a spring. The integral cylinder *B* and piston 4 are normally held away from the nose of piston 3 by a light spring and total movement of the unit is limited by the snap ring shown. All cylinder chambers are normally open to the reservoir and the various parts are positioned as illustrated when the unit is inoperative.

As the piston 1 is moved left, the friction between the seal cup of piston 1 and the wall of cylinder *A* will move the entire assembly to the left. This movement engages the nosepiece of cylinder *C* and the seat, sealing off the reservoir fluid. Piston 1 then moves in relation to cylinder *A*, developing a pressure in the outlet passage. The pressure developed will act on the inner face of cylinder *C* to retain the sealing position of the assembly. Pressure differential created between cylinder *B* and cylinder *C* will force piston 4 to the right, effecting a seal of the seat in cylinder *B* against the nose of piston 3. Continued movement of piston 1 directly moves piston 2 with 3 and 4 to develop additional pressure in the outlet passage. Fluid trapped by piston 2 escapes to the reservoir through the orifice in cylinder *A*, thus controlling the further application of pressure. As cylinder *C* becomes effective less force is required from the operator to increase pressure to the system.

Release of piston 1 by the operator will drop pressure in cylinder *A*, allowing piston 2 to move to the right. System pressure ahead of piston 4 will retain the seal against the nose of piston 3 and when piston 2 reaches the stop ring, cylinder *A* is carried back to initial position. Thus the remaining system pressure is relieved to the reservoir and all parts return to initial settings.

By employing the small orifice in cylinder *A*, fluid is restricted from flowing back into the reservoir. This acts as a check against excessively rapid movements of piston 2. It also guarantees the sealing movement of piston 4 prior to advance of piston 2. Another means for accomplishing this result is shown in the sectional illustration and employs an orifice plate retained by snap rings. The flow into the reservoir from cylinder *A*, however, is unrestricted in the alternate design and pressure developed by piston 1 is metered through the orifice to control and check the movement of piston 2.



An orifice port in cylinder A of this compound master cylinder unit controls the application of pressure to the system. Pressure developed is smooth and gradual


YEAR after YEAR after YEAR after YEAR after YEAR
Long Life
The life of a Sleeve Bearing is figured in years . . . not months. It is not unusual for us to learn of instances where Johnson Sleeve Bearings have been in continuous operation for fifteen . . . twenty . . . twenty-five years. And still delivering efficient performance.
There are several reasons why these records are possible. For instance, every Johnson bearing is made from the highest quality metal available. Every manufacturing operation is laboratory controlled. Johnson bearings are "tailor-made" to suit the application . . . to meet the operating conditions. Sleeve bearings are simple in construction . . . no moving parts within the bearing to fail.
Helping manufacturers to build real service into their product is a welcome assignment for Johnson Bronze. Simply call in a Johnson Engineer. Permit him to study your applications. Provide him with adequate information . . . speeds . . . loads . . . shock . . . or other operating conditions. He will give you the right solutions . . . based on facts . . . free from prejudice. Manufacturers giving thought to their postwar product will do well to consult with Johnson Bronze now.
JOHNSON BRONZE CO.
525 S. MILL ST.
NEW CASTLE, PA.
Branches in 18 Industrial Centers
JOHNSON
SLEEVE BEARING HEADQUARTERS
BRONZE

ASSETS to a BOOKCASE

Metals and Alloys Dictionary

By M. Merlub-Sobel, consulting chemical and metallurgical engineer; published by the Chemical Publishing Co., Inc., Brooklyn, New York; 238 pages, 5¼ by 8½ inches; clothbound; available through MACHINE DESIGN, $4.50 *postpaid.*

This concise dictionary of metallurgical terms should be of great value to the machine designer, regardless of his rating. The author has attempted to fill a void, hitherto somewhat overlooked, by creating a ready reference for anyone requiring a working acquaintance with the applications and peculiarities of metals, alloys, and raw materials used in metallurgy.

Presentation of the material has been made with the desire in mind to serve workers at the bench and behind the torch no less than technologists with extensive training. Hence, definitions of many words and phrases of metallurgy have been included and the book as a whole constitutes a volume admirably suited to the machine designer's requirements. Composition, properties, and uses of important commercial alloys are given in short, clear descriptions and on a strictly alphabetical basis. Much new data drawn from the author's experience, especially in the realm of rare metals, have been included, as well as physical constants and properties of chemical elements, descriptions of machinery and processes used in modern metallurgy, and other pertinent information.

Compromise between undue bulk and incompleteness has been handled deftly by the author. The resultant fine volume forms a further link between the machine designer and the metallurgist.

□ □ □

Heating, Ventilating and Air Conditioning Guide 1944 Edition

Edited and published by the American Society of Heating and Ventilating Engineers, 51 Madison Avenue, New York; 1168 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, $5.00 *postpaid.*

Broader in scope and variety, the 1944 edition of this guide should have a place in the library of every mechanical engineer engaged in the air conditioning field or associated industries. The many pages of condensed data on equipment should be helpful in design, installation and selection of equipment.

This twenty-second edition is presented with many important changes and additions, providing an up-to-the-minute text on the latest developments in the heating, ventilating and air conditioning fields. By careful condensation of the existing text, space was provided for much current material without the sacrifice of any essentials or expansion of the prevailing book size.

A new chapter dealing with marine heating and ventilation has been added. Tables of heat transmission coefficients have been completely revised and rearranged to include values for important materials and constructions not previously listed and to eliminate obsolete or seldom-used constructions. New findings on fuels and the combustion process have been included. A chapter on chimneys and chimney draft calculations is largely new and has been brought in line with recent developments, including chimneys for gas heating. Advanced information on mechanical stokers, oil burners, and gas-fired heating equipment is contained in a chapter on automatic fuel-burning equipment. New specifications are given covering commercial pipe dimensions as well as current information on pipe-threading practice. Also included are new specifications on conduits, meters, piping of meters and economizers, and revised rules for utilization of heat. State code references have been brought up to date to include 1944.

The catalog section, which covers apparatus and materials manufactured to meet the requirements of this field, has been somewhat enlarged. Comprehensive in scope, the information is cross indexed to coordinate it with relevant technical material in the text.

□ □ □

Practical Design of Welded Steel Structures

By H. Malcolm Priest, engineer, Railroad Research Bureau, U. S. Steel Corp. Subsidiaries; published by the American Welding Society, 33 West Thirty-ninth Street, New York; 153 pages, 5 by 7¾ inches, clothbound; available through MACHINE DESIGN, $1.00 *postpaid.*

Written to promote a better understanding and a clearer comprehension of the natural characteristics of proper welding design, this book presents the essentials of the design of welded steel construction with the background information required.

Treated are all the latest developments in welding engineering and their influence upon design. Much study has been given the problem of properly utilizing the inherent rigidity of welded connections to achieve economy of material. Quality, stress concentrations and costs are outstanding among the points discussed which merit attention. The important codes and specifications of the American Welding Society are listed at the end of the book.

Although structures such as bridges, buildings, etc., are covered extensively in the book, the general principles of sound welding design as outlined are applicable to many phases of the machine field.

Offner Electric Shock Therapy apparatus has been widely prescribed for treatment of psychiatric patients for more than five years. From the very first experimental model to present-day production units, Guardian Overload Relays have been used exclusively to protect the patient from dangerous current surges.

Relays BY GUARDIAN

In certain types of mental disorders it is possible to shock patients back to normal by passing an electric current through brain tissues. Naturally the patient must be protected against the possibility of excessive current surges. Such protection must be positive—dependable. In providing this protection, Guardian Series L Overload Relays have established a perfect record for safe, dependable performance in hundreds of thousands of known treatments.

The Series L Overload Relay provides accurate protection against surges and overloads. Standard coils attract on 150, 250, 500, or 750 milliamperes; coils for operation on other current values are available on specification.

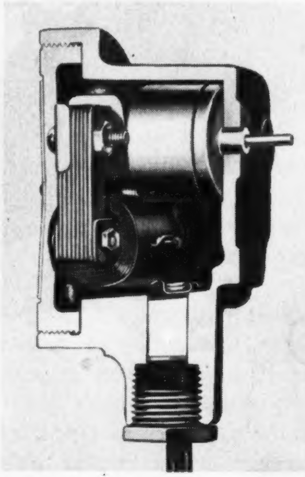
The large, oversize contacts used on this relay can take severe overloads without damage. They are rated for 1500 watts on 110 volt non-inductive A.C. and in A.C. primary circuits of any inductive power supply delivering up to and including 1 kilowatt. Contacts lock open and cannot be reset until overload is removed. For further information, write for Series L bulletin.

Consult Guardian whenever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications, but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN G ELECTRIC
1601-B W. WALNUT STREET **CHICAGO 12, ILLINOIS**
A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

New PARTS AND MATERIALS

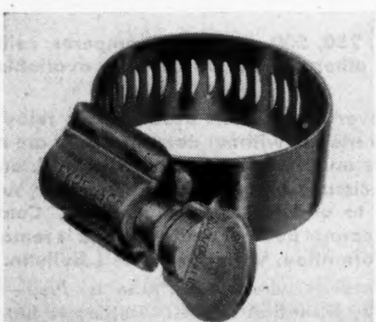
Explosionproof Motor



DEVELOPED BY Warren Telechron Co., Ashland, Mass., a new explosionproof electric motor is primarily for use in connection with automatic controls in industrial processes where atmospheres contain ethyl ether vapor, gasoline, petroleum, naphtha, alcohols, acetone, lacquer solvent vapors and natural gas. Already in use in some of the war plants producing chemicals, synthetic rubber, high-octane gas, and ammunition, the new motor is totally enclosed in a bronze casting with removable screw cover, and adapted for explosionproof conduit mounting. It is available in various shaft speeds, voltages and frequencies, and carries the Underwriters' approval label, Class 1, Grade C and D, for hazardous locations.

Stainless Steel Hose Clamps

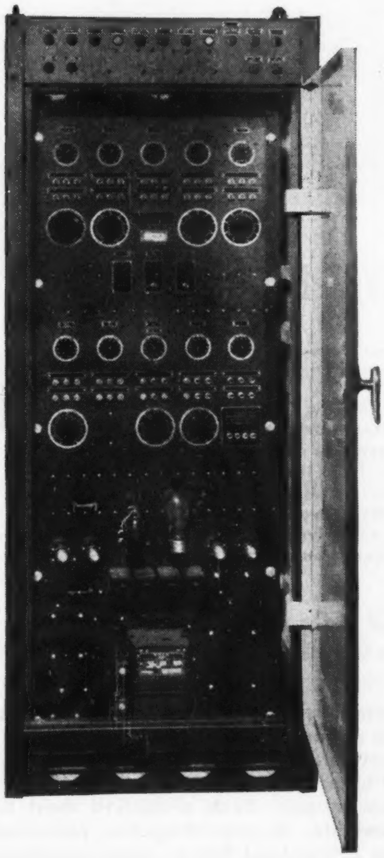
DESIGNED FOR service where high corrosion resistance is required, the new all-stainless steel Aero Seal hose clamps are being produced by Aircraft Standard Parts Co., 1727 Nineteenth avenue, Rockford, Ill. They



are available in the following sizes now: M12, M16 and M20, but the range will be increased gradually to include all nominal sizes from ½-inch to 4¼ inches. The stainless bands, although light and thin, have good strength and are flexible and rustproof. They include the same basic characteristics as the company's other Aero Seal designs. These are: Powerful worm gear drive, compact housing, no loose parts, openable band, vibrationproof holding, wide range, long take-up, uniform pressure, no distortion of thin-wall tubing, and ability to hold high pressures without leakage.

Weld and Sequence Timer

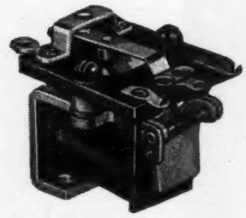
ANNOUNCED BY THE Industrial Control Division, General Electric Co., Schenectady, N. Y., a new weld and sequence timer provides various time and current adjustments for welding heavy sections of air-hardenable steels. Known as Type CR7503-F170 and designed for



use with the company's ignitron contactor and heat control panel, it can also be used in combination with most G-E spot-welding controls which include the phase-shift method of heat control. Operating from 230/460/575 volts, 60 cycles, the control adjusts time of current flow and its magnitude for preheating, welding, grain refinement and tempering, as well as time for chilling the weld nugget following the weld and grain refinement

periods. For variations in control voltage of plus ten to minus 20 per cent, consistency of timing will be within plus or minus one-half of 1 per cent of the time setting, according to the manufacturer. It is, however, recommended that a G-E current regulating compensator be used with this combination to correct for variations in welding current caused by line voltage variation or introduction of magnetic materials.

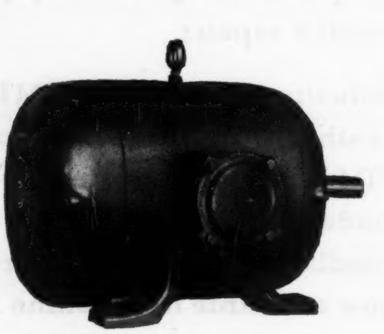
Small, Lightweight Relay



FOR APPLICATIONS where weight and space are at a premium, a new lightweight, midget relay has been developed by Guardian Electric Mfg. Co., 1601 West Walnut street, Chicago 12. The weight of the relay is 1.2 ounces and overall dimensions are 1 9/32 x 1 5/32 x 29/32 inches, single-pole, single-throw. The relay operates on direct current only and has a switch capacity of 1.5 amperes. Power requirement is 1.75 watts.

Motors for Hazardous Locations

ANNOUNCED BY Century Electric Co., 1806 Pine street, St. Louis 3, is a new explosionproof motor for operation in ethyl ether vapors. The motor is constructed to meet the specifications of and carry the label of Under-

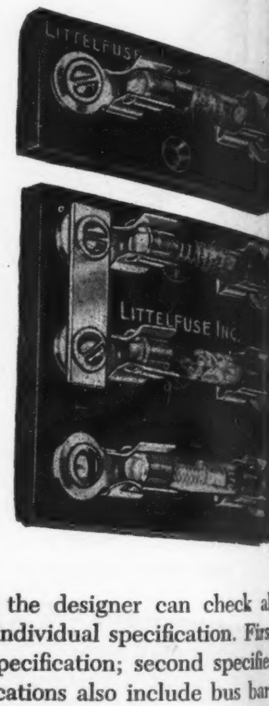


writers Laboratories Inc. for Class I, Group C installations where the surrounding atmosphere is charged with ethyl ether vapor. This is an addition to the company's other explosionproof motors for other hazardous locations.

One-Coat Enameling Alloy Steel

THROUGH THE development of a new vitreous enameling alloy steel, recently announced by Inland Steel Co., 43 East Chicago street, Chicago 11, white or light pastel cover-coat vitreous enamels may be successfully applied directly to steel surfaces. This material to which vitreous enamel can be applied directly without the prior application of a base or ground coat enamel is known as Inland Ti-Namel Steel. It was found that by adding titanium in a quantity dependent upon the amount of carbon in the base of the metal, the cause for pitting, black specking and blistering which previously showed through the one coat of enameling, would be eliminated. Some of the outstanding characteristics of the new material are its drawing properties which are equal to the deep drawing iron and steel sheets, including carbon steel sheets. Also the material does not age-strain. It has high resistance to sagging so that shallow panels of large areas remain flat and true to required shape and form. Enameling properties of the new alloy steel are excellent, permitting satisfactory white enamel finishes with a total thickness of from .006 to .009-inch, depending on whether the applications is for an interior or exterior part. These thin coats have high reflectance and the advantage of reducing the chipping hazard.

Electrical Fuse Panels



ELECTRICAL FUSE panels to individual specifications are now available to manufacturers of electrical equipment. According to Littelfuse Inc., 200 Ong street, El Monte, Calif., the panels have especial advantages for airplane application. They can be placed at an accessible point rather than in a central junction box. The new fuse panel No. 1505 is for use with 3 A G and 3 A B, 4 A G and 4 A B, and 5 A G and 5 A B Air Corps type fuses and clips. One number is the mounting. Blueprints may be obtained and the designer can check all the factors for panels for his individual specification. First dash number indicates fuse specification; second specifies the number of poles. Specifications also include bus bars if required, and number of poles to be bussed. The panels to individual specifications are furnished ready to mount.

New Industrial Power Tube

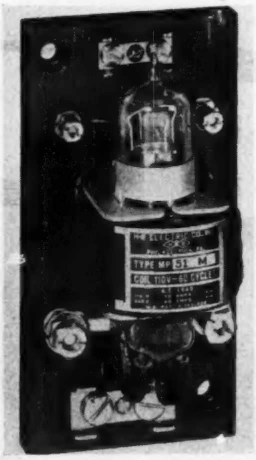
FOR INDUSTRIAL USE in high-frequency heating equipment, a new power tube has been developed by Federal Telephone & Radio Corp., Newark, N. J. Designated as F-5303 the tube is supplied with 6-inch flexible copper leads secured to the tube terminals, eliminating glass damage encountered in attaching and adjusting terminal clamps on the tube itself. Its sturdy, conservatively spaced filament and grid elements, and an absence of ceramic insulation make the tube suitable for use in electronic heating equipment that must withstand shock and vibration. Rated at 3500 watts input, it operates at full ratings at frequencies up to 50 megacycles. Maximum ratings are: d-c plate voltage 3500 volts, d-c plate current 1 ampere, plate dissipation 1200 watts. The filament current is 27.5 amperes at 11 volts. Overall height


FORT PITT
Stainless Steel
CASTINGS

of the tube is approximately 7 inches with a maximum diameter of 3½ inches. While Model F-5303 is designed for forced-air cooling, it can also be supplied for water cooling in Model F-5302.

Plunger Relay Announced

AS FURTHER improvement in the mercury plunger relay of H-B Electric Co., 6111 North Twenty-first street, Philadelphia 38, a new crown-shaped wire guide has been incorporated as a part of the plunger. This guide keeps the plunger upright and friction-free permitting a quick, clean break. In addition, the arc is broken over a hardened ceramic material, eliminating powdering. Of normally open type, the plunger relays are available for alternating current up to 440 volts and direct current up to 250 volts, with contact capacities as high as 30 amperes. All have hermetically sealed mercury-to-mercury contacts.



Rubber Coupling for Aviation

ANNOUNCED BY the aeronautical division of The B. F. Goodrich Co., Akron, O., the Flexlock coupling is adaptable to aviation uses such as high-pressure grommet seals, for passing lines into or through liquid containers such as integral fuel tanks, for passing conduits through bulkheads of pressure chambers, as a flexible joint for wiring or control cable conduits and as a flexible joint for bell and spigot tubing for the transferring of gases

and liquids. The coupling is a gasket or ring having ribs or fins running circumferentially both inside and outside. Inside fins not only grip the outside surface of the smaller pipe but also furnish a sealing pressure. The outside fins are so designed that as the deformation of pack takes place and the fins grip the bell or sleeve of the outer pipe, they set up strut action through the cross section of the coupling, driving the joint tighter. For aeronautical uses the couplings are offered in either natural or synthetic rubber, depending upon service conditions. Various compounds to meet specifications have heat ranges from −50 degrees Fahr. to 150 degrees Fahr., and can be made resistant to petroleum products and aromatics, as well as hot and cold gases and liquids such as commercial acids, alcohol, water, gasoline and oil. The couplings are available for ¾, ⅞, 1, 1.20, 1½, 2, 2⅝ and 3-inch outside diameter pipes or tubing.

Midget Type Relay

FOR COMMUNICATION, electronics and aviation applications, the new midget type relay announced by Betts & Betts Corp., 551 West Fifty-second street, New York 19, is hermetically sealed in a metal shell for performance under severe conditions of temperature, humidity, pressure, dust, corrosion and fungi. Units are normally sealed with content of prefiltered dry air but can be furnished with inert gas or pressurized content if desired. Coil

windings can be supplied for voltage ranges from 1.5 to 70 volts direct current, and are wound to exact number of turns. Inorganic-base plastic insulation minimizes high frequency loss and assures permanent dielectric and mechanical strength. Contact arrangements offer flexibility in arrangement and handle 2 amperes at 100 watts. Dimensions of the unit are 1 11/16 inches long and 2 7/8 inches wide, including prongs. Weight is 4 ounces.

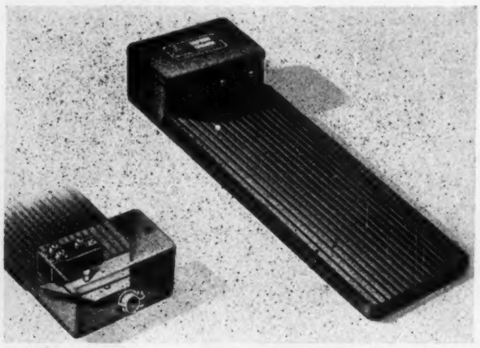
Protective Finish for Fabric

FOR APPLICATION to airplane fabrics, a new protective finish known as "Hot Dope" or the "Thermotite" system, has been introduced by Sherwin-Williams Co., Cleveland. Strengthening and stiffening the fabric, it comes close to duplicating the strength of some light metals. "Hot Dope," as the name implies, is dope that has been heated to convert it from a molasses-like syrup to free-flowing consistency for spraying. The device which provides a constant supply of hot dope at the point of spraying is known as the "Thermotite" system and consists of a simple arrangement of heating coils, pressure tank, air pump and spray gun. While this type of finish has been

used previously for finishing wings or stabilizer surfaces, the new development reduces the number of operations to seven. The finish is applied to airplane fabrics on gliders and for attaching fabrics to plywood plane sections on transports and combat planes.

Flat Foot Switch Offered

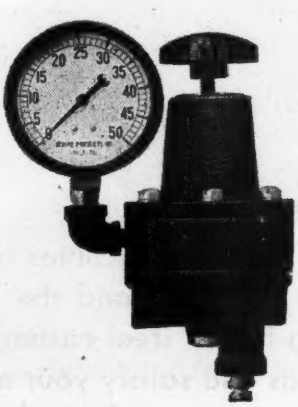
FOR ACTUATING one to eight circuits a new foot switch is being offered by General Control Co., 1200 Soldiers Field road, Boston 34. Known as Model "MF",



this flat switch has a foot rest one-half inch above the floor and requires only a one-sixteenth inch throw. This allows the operator to support his whole foot nearly at floor level. The switch is splash and dustproof.

Regulator for Air Pressures

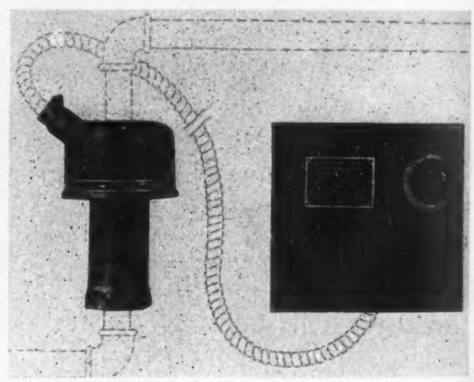
SET AIR PRESSURES are held practically constant, regardless of changes in flow and variations in supply pressures, by the new regulator being offered by Moore Products Co., H and Lycoming streets, Philadelphia 24. The new regulator operates on the pneumatic "Null" balance principle, and may be described as a pressure con-



troller since the main air valve is operated by a detecting nozzle. The nozzle operates with a constant differential pressure to hold the manual loading spring at the same position. To operate when a reduced regulated pressure is required, an automatic bleed is provided which serves also to permit reverse flow when the regulator is used as a limit control. A separate safety release is incorporated in the design. The neoprene diaphragms used are for continuous operation at temperatures to 225 degrees Fahr. Available in three standard ranges—0-30 pounds per square inch; 10-50; and 20-80—the regulator is suitable for use on supply pressures up to 150 pounds per square inch. With 100 pounds per square inch supply pressure and 25 pounds per square inch regulated pressure, maximum capacity is approximately 10 standard cubic feet per minute.

Liquid-Level Control

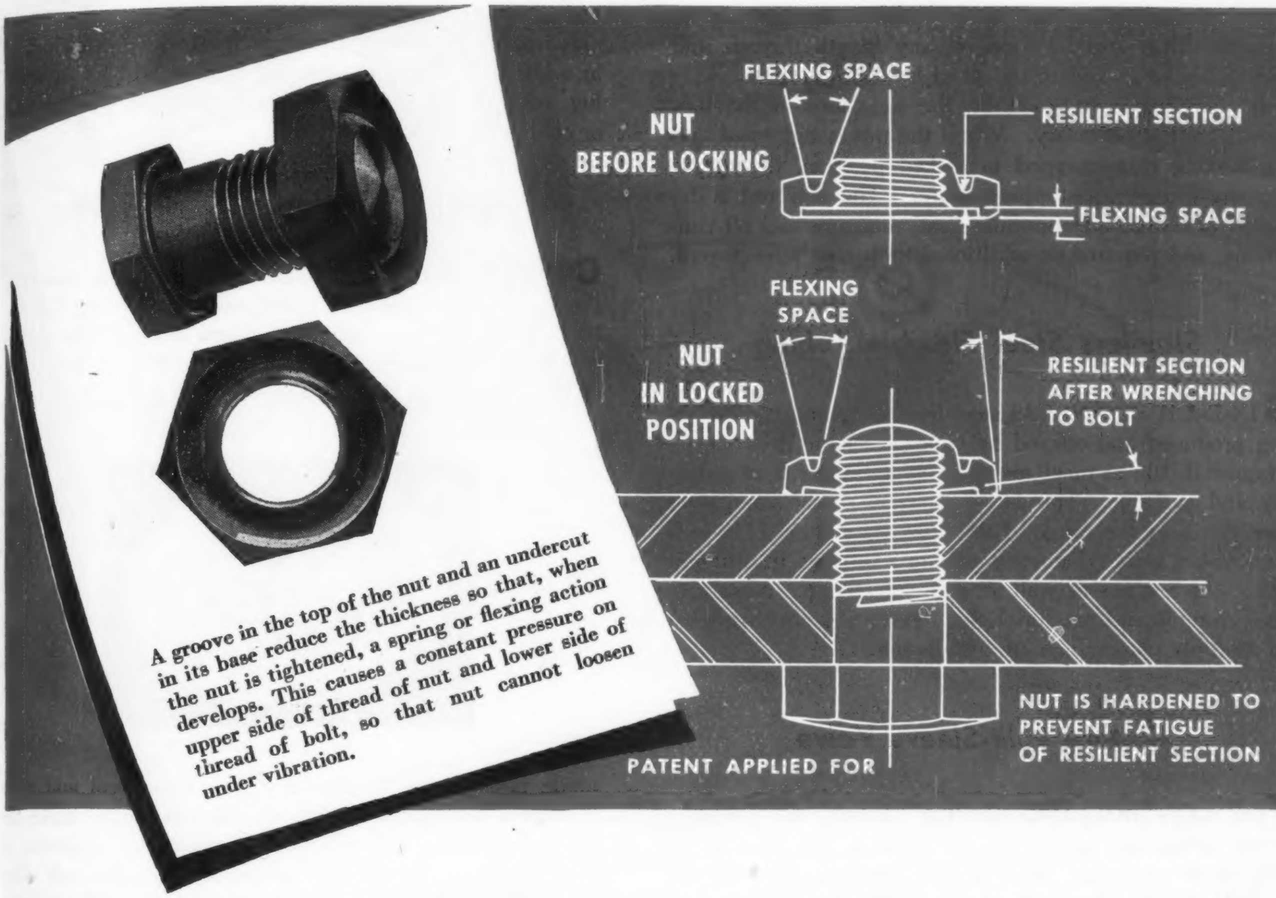
FOR USE IN the refrigeration industry, breweries, chemical processing plants, dairies, distillers, home and industrial heating plants, pulp and paper mills, in refineries, etc., the new level control of Hancock Valve Division, Manning, Maxwell & Moore Inc., Bridgeport 2, Conn., provides accurate liquid level to within a fraction of an inch. This automatic control has no levers, linkages, bellows, stuffing box, cooling fins, mercury switches, or wearing parts. The operating principle is as follows: When the float is pushed into the field of the coil due to an increase of liquid level, the total impedance of a



fixed coil is increased. This change causes a relay to operate in a separate unit, the controller, and a valve or other cooperating device to function. When the float moves out of the coil because of a drop in liquid level, the coil impedance decreases and the controlled equipment is returned to its first position. The standard low-pressure model is for pressures up to 300 pounds and temperatures up to 200 degrees Fahr., while the high-pressure unit is for pressures up to 500 pounds and temperatures up to 500 degrees Fahr. The standard low-pressure controls operate on a differential of ½-inch.

Dual-Purpose Safety Nut

DUAL-PURPOSE safety nuts introduced by the Simlok Fastener Division of Simmons Machine Tool Corp., Albany, N. Y., feature installation ease and safety, and have many application possibilities for all mechanical industries. The nuts operate on the principle of the engagement of a snap ring in one of a number of longitudinal serrations in the bolt thread. With seven serrations on the bolt



MAKE SURE *YOUR* PRODUCT WON'T HAVE THE

"WOBBLES"

This is no ordinary bolt and nut. It is new and unique . . . a custom-made cure for the "wobbles". It illustrates how manufacturers are improving their products by consulting with National *on fasteners:*

The American Fork and Hoe Company, in redesigning their new line of "True Temper" products, needed a bolt and nut assembly for certain applications that would lock up tight, yet permit delicate adjustment for proper functioning of the tools, and be capable of easy disassembly for sharpening.

The nut had to be thin, light in weight, one-piece construction. Existing types of lock nuts were too cumbersome.

They put it up to us to find the answer. We designed a new type of lock nut (patent applied for) which, when tightened, develops a *spring* or *flexing* action that eliminates the possibility of the nut loosening in action.

Appearance was a factor, too. This was improved by making the top of the bolt slightly oval, and rounding the point so as to blend in assembly with the radii of the nut.

Let us diagnose *your* products for possible fastener improvement. It's often surprising what can be done.

National
PRODUCTS

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

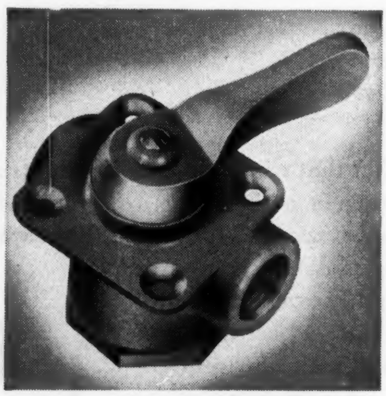
thread, there are fourteen locking positions per revolution of nut. They can be used on any length threads and may easily be locked or unlocked by a flip of the locking ring. For use as a stop nut, the serrations in the bolt thread are not necessary. When the nut is tightened and the locking ring snapped in locked position, the spring pressure provides a stopping action. The new nut is designed to withstand abnormal heat, moisture and oil conditions, and requires no additional torque or wrench-pull.

Stainless Steel Flexible Tubing

SIX-INCH STAINLESS steel flexible tubing is now being produced and offered by Chicago Metal Hose Corp., Maywood, Ill., to meet many new requirements of industry and aviation. This latest addition to the company's line increases the range of Rex-Flex sizes from 5/16-inch to 6 inches inside diameter, making a total of 16 different sizes and 5 types of wall structure available. Noncorrosive, durable and pressure-tight, Rex-Flex is also bendable in multiple planes for easy installation.

Rotary Split-Sleeve Valve

FOR CONTROLLING the flow of fuel, oil, gasoline, water, steam and practically all fluids, a new type rotary split-sleeve precision valve has been introduced by Clarke Aero-Hydraulics Inc., Pasadena, Calif. Due to its construction of sealing parts, it expands and contracts in



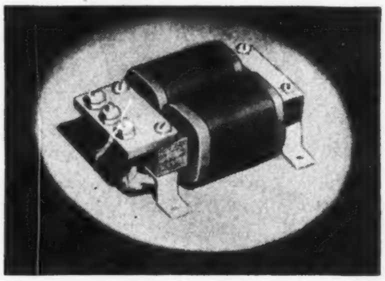
conformity to pressures and temperatures. It will not freeze or bind, is leakproof and is unaffected by vibration. In the illustration is shown a two-way model in ¾-inch size, capable of operating under pressures up to 1000 pounds at temperatures from −65 to 160 degrees Fahr.

Pre-Cut Masking Stickers

FOR MASKING NAME and instruction plates, a new method has been developed by Avery adhesives, 451 East Third street, Los Angeles 13. Under this new system the company's Kum-Kleen masking stickers are die-cut to the specifications of the manufacturer. The nameplate is attached on the production line, covered with the precut masking sticker, then painted or finished. These stickers in addition to being die-cut are applied without moistening, stick to any smooth surface, are not affected by heat or cold and peel off easily.

Small, Light Autotransformers

CONSTRUCTED TO withstand shock and vibration, the new autotransformers introduced recently by General Electric Co., Schenectady, have been designed for operation from line-to-neutral on 400-cycle, 120/208 Y-volt aircraft electrical systems. The small size and light weight,



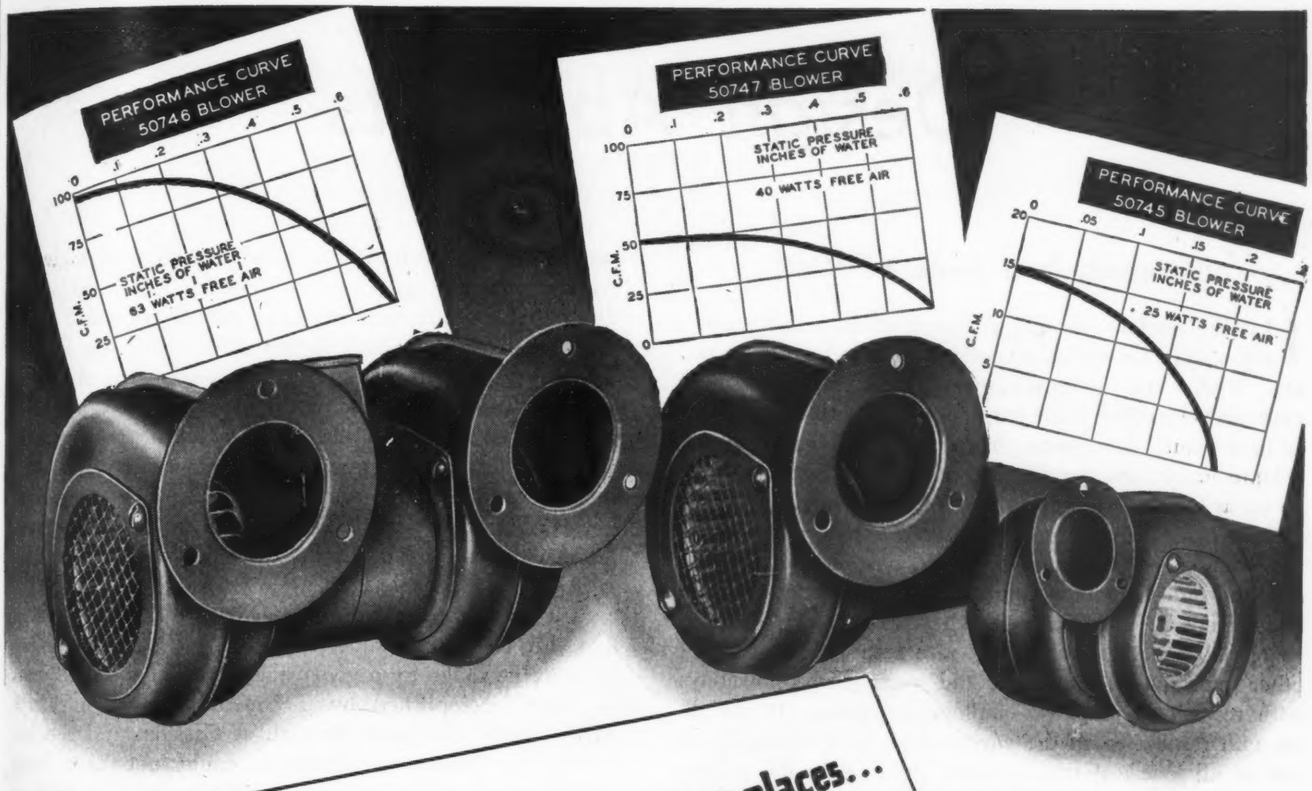
made possible by the use of a new core steel and glass insulation impregnated with an inorganic resin, make the autotransformers particularly adaptable for operation of 28-volt lamps, electrically heated flying suits and other low-voltage aircraft accessories. They will function properly in temperatures from −40 to 140 degrees Fahr., and are suitable for operation at any altitude from sea level to 60,000 feet, over a frequency range from 380 to 420 cycles.

Fabric-Base, Phenol Fiber

DEVELOPMENT OF a Phenolastic Fiber has been announced by Taylor Fibre Co., Norristown, Pa. This new material is a fabric-base phenol fiber with the added advantage of greater elasticity, obtained by a special weave in the base material of the fiber and rearrangement of the resin formula and coating procedures. With the new fiber, it is possible to change the shape of a flat sheet to conform with almost any bend, curve or draw within three minutes or less.

Aluminum Structures Offered

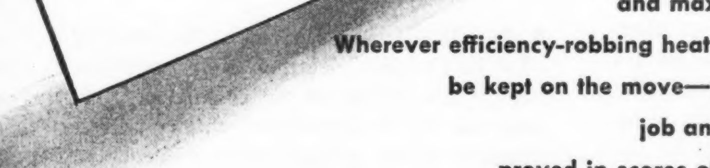
STRUCTURES manufactured by Lindsay & Lindsay, 222 West Adams street, Chicago, are now being offered in aluminum as well as steel. A weight saving of 50 to 60 per cent is possible with aluminum which also possesses the same strength-weight ratio and ease of assembly features as the steel construction. Structure panels are 61 ST alloy sheets, .020-inch or .025-inch thick. Adequate rigidity is provided for a variety of applications such as cabinets for electrical and electronic equipment, refrigerator units, food processing equipment, small machine housings, and similar applications. The aluminum structure is also being used for truck and trailer bodies in sheets of .030-inch thickness.



These little blowers are going places...

Yes, Pilot Centrifugal Blowers *are* going places . . . going into many types of electronic devices where minimum size and maximum performance are prime essentials. Wherever efficiency-robbing heat is to be dispelled . . . wherever air must be kept on the move—you can count on Pilot Blowers to do the job and do it well! Their dependability is being proved in scores of diversified applications—many directly connected with the war effort. Bulletin 507 gives specifications in detail—write for it.

F. A. SMITH MANUFACTURING CO., INC.
401 DAVIS ST., ROCHESTER 2, N. Y.



• SHADED POLE F.H.P. MOTORS •

Tell us your requirements and we will send you complete specifications on these dependable, efficient, low-cost Motors. For continuous or intermittent duty with H. P. ratings ranging from 1/15 to 1/500 H.P. and from 1550 to 3400 R.P.M. Plain round or with base or resilient mounting . . . open or enclosed cases.

Pilot *Shaded-Pole* **MOTORS & BLOWERS**

Design Abstracts

Research Is a State of Mind

I LIKE to define research in broad terms as systematically setting out to find something new and worth knowing. Under this definition research is something much more universal than what goes on in a scientific laboratory or in a plant. It includes, but is not limited to, the development of new products and new processes. It can go on in a sales department in the form of market surveys and the like. It can go on, without the help of any apparatus whatever, in the mind of a salesman on the road. It can, and indeed must, go on plentifully in every personnel department in the country, both with respect to hiring, firing, job specification setting, rate setting, and a lot of other personnel techniques, and particularly nowadays with respect to employer-employee relations. It can go on with respect to all the various aspects of management and at all levels of management, right up to the policy-setting level sometimes called administration.

In other words, research is not a particular kind of activity, it is a state of mind. The spirit of research never assumes that because something has been it is necessarily the best that could be. Often it is, but the possibility of improving it is always worth thinking about. The spirit of research is an imaginative asking of a lot of significant questions, coupled with a yearning for as much knowledge as can be had before one reaches a conclusion. Both this imagination and this yearning for facts is, or should be, characteristic of technically trained men. But remember, also, that a good research man often gets some of his most useful facts by means of a literature search in the library, or by conversation with others, as well as by experimentation on his own hook, so never ignore the accumulated wisdom of the race. But never swallow it whole.—*From a recent address by Harvey N. Davis, president, Stevens Institute of Technology.*

Heavy Tanks vs. Medium Tanks

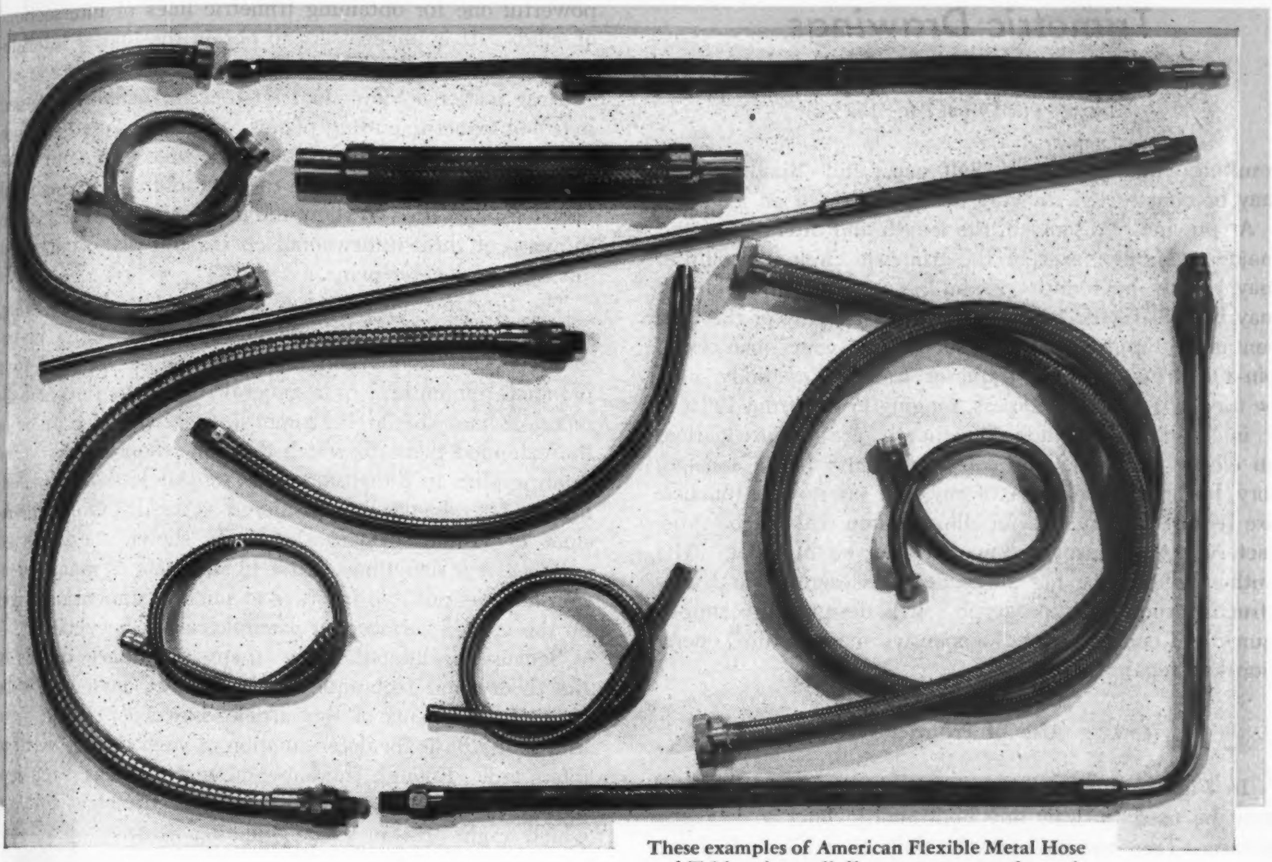
ALARMING reports have been published describing the German Tiger and King Tiger tanks. These are formidable weapons which, because of their 64 and 74 tons weight, do carry a larger gun and heavier armor than does our medium tank, M4. It will be recalled that our heavy tank, M6, with a weight of 62 tons, was developed in 1940, and was produced in limited quantities. At that time and for a considerable period thereafter, the M6 was the most powerful in existence. However, our Army Ground Forces decided not to use this tank in overseas theaters. With shipping a bottleneck in the conduct of this war, they preferred two M4 medium tanks rather than one M6. Port facilities which can handle 62-ton tanks were limited or nonexistent. Most American railcars have only a 40-ton capacity; most foreign cars are limited to a 25-ton load. Load capacities of highway bridges restrict action of a heavy vehicle to limited areas. The difficult problems of training, maintenance and spare parts at the end of long supply lines would be further complicated. Further, our fighting forces are offensive-minded. To them a tank represents mobile fire power—something to fight from and not to hide in. On the other hand the Germans are now fighting a defensive war with short lines of communications, and their heavy mobile fortresses interspersed among the pill boxes of the Siegfried Line, with intentionally limited field of operation, begin to play their ideal role.

In a break-through, the equivalent weight of medium tanks can cover two roads, go twice as fast, and have twice the mileage range for a given quantity of fuel. Such feats as were accomplished by the medium tanks in North Africa, Sicily, the break-through at Cassino, and the liberation of France and Belgium could not have been accomplished with a tank of the Tiger class. In fact, in these battles the Tiger tanks were left behind, were too slow to head off the medium tank, were restricted in movement to limited terrain, and were soon helpless—out of gas. *—From a paper by Colonel Joseph M. Colby presented at the recent War Engineering annual meeting of the S.A.E. in Detroit.*

Electronics in Textile Machines

MUCH has been said about the possibilities of devices that employ electronic tubes, particularly those that include the phototube or electric eye. Ever since the doors in the Pennsylvania station in New York were arranged to be opened when passengers interrupted a beam of light, every textile man that has passed through the station has thought to himself: "Why can't we use that on our machinery?" Some of us did try, but did not accomplish much because the first photoelectric relays were too slow. Thanks to electrical engineers and scientists, that situation has changed. Electronic relays now available are fast enough to be used on loom mechanisms, such as stop motions and filling detectors. But still they are not applicable in all cases, not because of any fault in them, but because of the inherent characteristics of the electrical apparatus with which they are used.

Electricity unhampered will travel at approximately the speed of light, but when it is introduced into the windings of a coil it becomes involved with something that electrical engineers call inductance. The effect is similar to that produced by the inertia of mass in a mechanical system. Perhaps it can be overcome, but at the moment inductance causes electrical circuits to be too slow for some of the operations which now are performed mechanically on looms — *From a paper by Albert Palmer, Crompton & Knowles Loom Works, presented at The Textile Society of Canada in Montreal, Quebec.*



These examples of American Flexible Metal Hose and Tubing, in small diameters, suggest the variety of assemblies available in factory-engineered and factory-assembled units.

Flexible...BUT RUGGED TOO!

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American Seamless Flexible Metal Tubing is as leakproof as the seamless bronze tube from which it is made, and flexible as garden hose. Its wire braided cover adds the strength needed for high pressure services. Standard sizes from 1/8" to 4" I.D.

American Metal Hose, manufactured from strip in four spirally wound types, is available in bronze, brass, aluminum, steel or any other workable metal. It is extensively used for carrying steam, water, oils, tar, asphalt, air, dust—and dozens of other agents under high and low pressures and for vacuum work. Sizes from 1/2" to 12" I.D.

Both types of "American" products can be fabricated completely with fittings and connections according to your specifications. Publication SS-50, giving complete information, will be sent on request.

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Subsidiary of Anaconda Copper Mining Company • *In Canada:* ANACONDA AMERICAN BRASS LTD., *New Toronto, Ontario*

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Trimetric Drawings

(*Concluded from Page* 152)

resulting trimetric will be "half size", etc. Similar scales may be constructed showing decimal parts of an inch.

As previously discussed, the length and direction of the major and minor axes of the trimetric circle, an ellipse, may readily be found. From these, an accurate ellipse may be constructed in a variety of ways. Any of the conventional graphical methods, such as the concentric circle, pin-and-string, parallelogram, or trammel methods, may be used. If accurate ellipses, ranging in size from 1/16 to 1 inch, with 1/16-inch increments, are required, then an ellipse guide may be constructed and found satisfactory, but if larger ellipses, of any size, say up to 20 inches, are required, then such an ellipse guide will not be satisfactory. An ellipsograph would then be in order. The author believes he has succeeded in designing and constructing such an ellipsograph. It is designed for simple, quick and comparatively inexpensive manufacture, operation and repair.

Use of Protractor

In *Fig.* 12 is shown a trimetric liner-protractor which may be used to draw any nontrimetric lines in trimetric planes. Trimetric lines may be defined as lines which are parallel to, or are lying in, the trimetric axes *X*, *Y* and *Z*. Trimetric planes may be defined as planes parallel to, or lying in, the faces of the trimetric cube. *Fig.* 14*c* shows how the protractor portion of this instrument may be used to lay off nontrimetric lines at any angle in trimetric planes. As there indicated, to lay off a line through point *A*, making 30 degrees with the vertical in the *ZY* plane in the ZU120 position, procedure is as follows:

1. With the ZU120 edge of the liner-protractor against the *top* edge of the T-square, draw the *Z*-trimetric line through point *A*, as in *Fig.* 14*a*
2. Slide the liner-protractor along the T-square edge to draw the *Y*-trimetric line through *A*, as in *Fig.* 14*b*
3. With the same edge of the liner-protractor on the top edge of the T-square, move the T-square and liner-protractor to set the four quadrant divisions of the proper ellipse on the lines drawn through *A*, and mark off the 30-degree angle from the vertical.
4. The required line contains point *A* and the point obtained in 3.

From the foregoing, it should be noted that the *Z* and *Y* trimetric lines of the liner-protractor were used to obtain the lines lying in the *ZY* trimetric plane. If lines were required in the *ZX* trimetric plane, in order to lay off any angle in this plane, then the *Z* and *X* trimetric lines of the liner-protractor would be used. Here the choice of which edge to use is determined as mentioned previously.

Irregular curves in trimetric may be obtained point by point. When the curve is in a trimetric plane, these points may be located by Method 2 by a grid of rectangular coordinates in the trimetric plane or by using offsets from reference lines. By Method 1, points on the irregular curve are projected directly from the three-plane orthographics. As *Fig.* 15 demonstrates, Method 1 is indeed a powerful one for obtaining trimetric lines of intersections of solids. It is unnecessary to obtain the line of intersection in the three-plane orthographics.

Most sectional views in trimetric are usually obtained by using trimetric cutting planes. These are used because it is not always possible to orient the object so as to make visible the desired portion in the pictorial view. Sectional views are also used to show the interior of an object, or in the case of three-dimensional curves the plane curve cut out by a parameter plane.

The fundamental rules and principles of dimensioning, as applied to pictorials, will automatically apply in trimetric. Dimensions and notes should be reduced to a practical minimum. As a general rule, extension and dimension lines should be trimetric lines and should lie in the extended plane to which the dimension applies. The same applies to dimension figures. All lettering, including figures, should be considered vertical. Only dimensions of visible surfaces should be shown. For curved surfaces, it is sometimes better to eliminate as many extension lines as possible in order to put the dimensions right on the curved surface, for example, along a cylinder.

Because of limited space, many secondary details of the theory and technique of the subject have had to be omitted. Contents of this article, however, should serve as a sound basis for determination of such details by those interested. Enough fundamental material has been presented to solve almost any practical trimetric problem which might arise in the engineering field.

Specifying Dynamic Balance

(*Concluded from Page* 166)

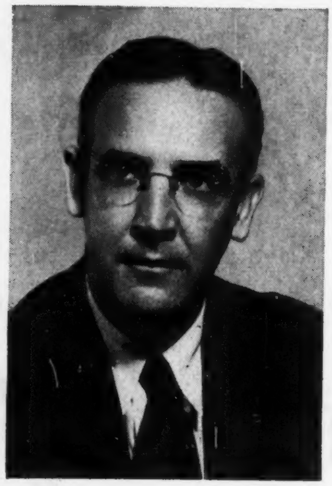
while measuring unbalance in the other end, the displacement of the free end is materially reduced. This reduces the potential machine accuracy.

Generally speaking, the work piece should be carried on plain bearings during the balancing operation. Roller type work supports are desirable in only a few cases and should only be used where facilities are available for maintenance of the rollers. They must be reground frequently to insure that they are absolutely round and do not cause motion of the work piece due to their out of roundness. This reconditioning of rollers requires extremely careful and accurate grinding. The use of rollers to carry work pieces with soft shafts is not desirable because the rollers tend to cut the shaft and to imbed into the shaft small dirt particles floating in the air.

In special cases, an extremely high accuracy of static balance is required in a work piece and small amounts of moment or dynamic unbalance may be neglected. For such cases, the balancing machine should be capable of measuring static (force) and dynamic unbalance effects separately.

In conclusion, to produce vibration-free, long-lived rotating parts requires the ultimate of cooperation between engineering and manufacturing departments. Each should know the problems of the other and they should work together for improvement in production. The use of understandable specifications for balance and equipment which can capably meet the specifications will give the desired result—an improved product.

C. G. Suits



P. S. Dickey

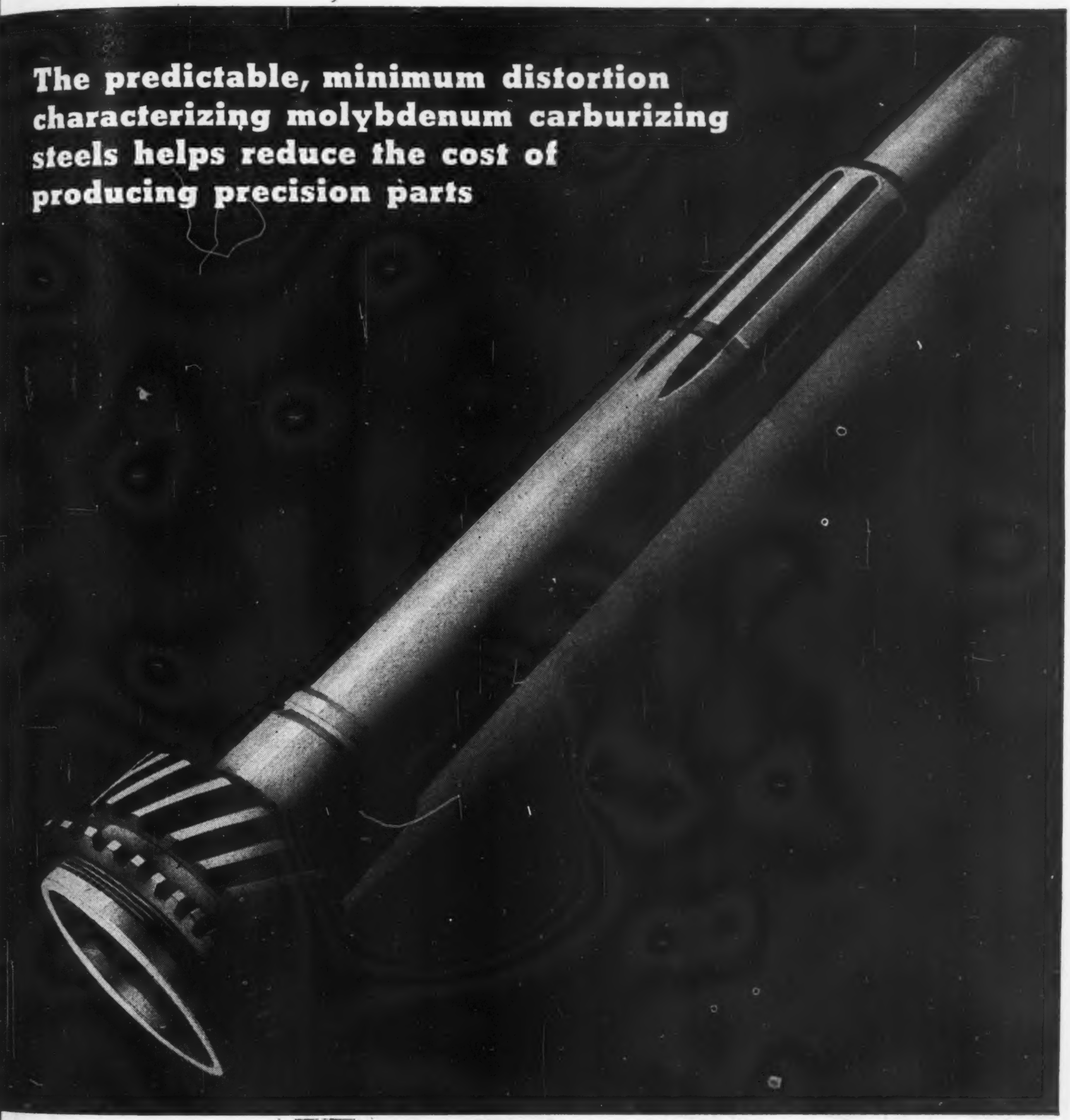
Henrik J. Eklund

MEN... of... machines

C G. SUITS in his new capacity as vice president will be in charge of the research laboratory of General Electric Co. He succeeds Dr. W. D. Coolidge who has retired as a vice president and director of the laboratory. Having been connected with the laboratory since 1930, Dr. Suits' position prior to his appointment was that of assistant to the director of the laboratory which post he held since October, 1940. While assuming some administrative duties of the laboratory in this capacity, he still continued his research. He is widely known for his work in high-temperature arcs, producing some of 18,000 degrees Fahr. Many of his sixty-two patents are in this field. During the war he has devoted his efforts to the direction of war research under the auspices of the office of Scientific Research and Development. As chief of Division 15 of the National Defense Research committee, he has also supervised the radio co-ordination activities of a group of scientists. Dr. Suits was born in Wisconsin in 1905 and was graduated in 1927 from the University of Wisconsin. He also was awarded a scholarship at the Institute of Technology, Zurich, Switzerland, where he obtained a degree of Doctor of Science in 1929.

P S. DICKEY, the new chief engineer of Bailey Meter Co., Cleveland, will supervise all engineering, research and design activities for the company, with the assistance of H. H. Gorrie who has been appointed assistant chief engineer. In his former position as research engineer, Mr. Dickey conducted numerous studies here and abroad on the problems involved in the control of both forced and natural circulation boilers in stationary, marine and mobile service. He is also an author of numerous patents, technical papers and articles on measurement and control as applied to power and process operations. A mechanical engineering graduate from Purdue university, Mr. Dickey has served in various engineering capacities with Bailey Meter Co., continuously since his graduation in 1925.

HENRIK J. EKLUND, chief engineer of D. J. Murray Mfg. Co., since 193 has been associated with the designing and development of paper and pulp mill machinery, both in the United States and Finland. He is therefore well fitted for his new post with the company (builders of paper and pulp mill machinery). He is in charge of designing,


The predictable, minimum distortion characterizing molybdenum carburizing steels helps reduce the cost of producing precision parts

pervising and development work. A graduate of the Polytechnic institute of Finland in mechanical engineering with a Master's degree, and with two years of post-graduate work at the same college, Mr. Eklund came to the United States in 1936. He has been associated with several of the outstanding paper mill machinery manufacturers since that time, such as E. D. Jones & Sons where he served as assistant chief engineer from July 1940 to July 1944. His experience prior to coming to the United States was that of machine designer with Machine & Bridge Co. Ltd., and G. A. Serlachius Co. Ltd., both pulp and paper mills and machine works of Finland. He also spent a part of a year in England designing machinery, after six months in Germany and Czechoslovakia on research and design work.

♦

D. E. Batesole, in addition to being chief engineer of the Norma-Hoffmann Bearings Co., has been elected vice president. A graduate of Ohio State university, Mr. Batesole began work in the design department of the Willys Overland Corp., and later taught engineering drawing at Ohio State. During World War I he served in the Signal and the Engineers' Corps. A member of the Norma-Hoffmann engineering department since 1917, Mr. Batesole has devoted much of his time to bearing applications in many fields. He holds numerous patents covering bearing designs as well as bearing mountings.

♦

Charles A. Cook has joined Wisconsin Axle Co., a division of Timken-Detroit Axle Co., as assistant chief engineer in charge of transmission engineering. He formerly had been executive engineer for the Fuller Mfg. Co.

Frank J. Nunlist, recently appointed chief engineer of L. J. Mueller Furnace Co., has been active in the heating and air conditioning industry since 1931. He has been with the company since 1940 and for the past year has served as acting chief engineer of the organization. A member of the American Society of Heating and Ventilating Engineers, he is on the Code Committee for rating heavy-duty furnaces, as well as the Technical committee for studying National Warm Air Heating and Air Conditioning association installation codes.

♦

Correction: MACHINE DESIGN apologizes for the transposition of photographs of K. Swanson and W. Kaiser in its December issue. Mr. Swanson had been appointed chief engineer of Progressive Welder Co., with Mr. Kaiser as his assistant.

FINISHABILITY!

—ZINC ALLOY DIE CASTINGS CAN TAKE ALMOST ANY KNOWN TYPE OF FINISH

The ability to take finishes easily and economically is one of the more important advantages of zinc alloy die castings over other commonly cast materials. This factor, combined with excellent mechanical and physical characteristics, accounts for the overwhelming preference for zinc alloy die castings among product designers.

All of the following finishes can be applied *commercially* on die castings of zinc alloy—electrodeposits, enamels, lacquers, paints, varnishes, chemical treatments, plastic coatings and decalcomanias. Shown above are a few well known products utilizing zinc alloy die castings with various types of finishes. Because of the exceptionally smooth surfaces obtainable with zinc alloy die castings "as cast", a minimum of preparation for the application of finishes is required.

It is the combination of many advantages, of which finishability is only one, that makes die castings of zinc alloy the most widely used under normal conditions. *Every die casting company is equipped to make zinc alloy die castings,* and will be glad to discuss their advantages with you—or write to The New Jersey Zinc Company, 160 Front Street, New York 7, N. Y.

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FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are specified with

HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC

Business and Sales Briefs

According to a recent announcement by General Electric Co., L. D. Fowler has been named assistant manager of sales of the integral-horsepower alternating-current motor section. Mr. Fowler will remain at the Oakland Works in California where he will direct the general office commercial activities in connection with the manufacture of electric motors there.

♦

With W. E. McDonough in charge as southern division manager, a new sales office at 413 Grant building, Atlanta, has been opened by Aluminum Industries Inc., Cincinnati. Mr. McDonough has been connected with the company for twenty years.

♦

Hewitt Rubber Corp. of Buffalo, N. Y., has placed C. F. Munroe in charge of mechanical rubber goods sales. Mr. Monroe, who will be located in the New York office, recently served as chief of the parts and subassemblies section, machinery branch of the OPA in Washington.

♦

Advancement of Archie J. Kashubeck to sales agent at the San Francisco office has been announced by National Malleable & Steel Castings Co. Mr. Kashubeck, formerly in the department of specialty development at Cleveland, will assist J. J. Byers who has directed the San Francisco branch for many years.

♦

Michigan sales manager for the past thirteen years, L. K. Lindahl has been appointed vice president in charge of national sales for Udylite Corp., Detroit. Donald C. Blum, who had been employed in the electroplating department of Samson United Corp., Rochester, N. Y., has been named service engineer for Udylite in the Buffalo and Rochester area. He will make his headquarters at 672 Mount Read boulevard, Rochester, N. Y.

♦

Associated with the company since 1924, W. A. Smith has been named manager of suspension sales for Industrial Products Sales division of The B. F. Goodrich Co. All suspension products including Vibro Insulators, devices of rubber and metal used for isolating vibration and noise, are handled by this division.

♦

With the appointment of the following three men, the sales engineering and development division activities of Aluminum Co. of America have been expanded: Frank Jardine, formerly in charge of development work in Cleveland, has been made manager of the development division at this branch. John R. Willard has been put in charge of the sales development division at New Kensington, Pa., while B. J. Fletcher

has been named chief engineer of the New Kensington branch. Each will report to R. V. Davies, who is the assistant general sales manager.

♦

Opening of an eastern office at 70 Pine street, New York, has been announced by Littelfuse Inc. Jack D. Hughes, former production manager of the Chicago plant, has been named eastern division sales manager and will work out of the New York office.

♦

Election of Allen Dale as vice president has been announced by Shook Bronze Corp., Lima, O. In his new position Mr. Dale will be in charge of the sale of finished bronze bushings and bearings, cored and solid bronze bars, etc.

♦

Previously assistant general sales manager, W. N. Shepard has been made sales manager of Plaskon glues and industrial resins for the Plaskon Division, Libbey-Owens-Ford Glass Co., Toledo, O. R. B. Harrison, formerly central district manager, has been appointed sales manager of Plaskon molding compounds. He and Mr. Shepard will both make their headquarters at Toledo.

♦

Carboloy Co. Inc., Detroit, has established branch offices at 924 M & M building, 1 Main street, Houston 2, Texas, with A. J. Rod, sales and service engineer, in charge. Branch offices have also been opened at 734 North Fourth street, Milwaukee, to provide service for the Wisconsin area. Both Frank J. Staroba and A. F. Schlumpf will work out of this office.

♦

Acquisition of Champion Aviation Products Co., Los Angeles, has been announced by Allied Control Co. of California Inc., manufacturers of wind and engine-driven generators, starters, relays, etc.

♦

With offices in the American National Bank building, Kalamazoo, Mich., E. B. Dewey has been made sales representative for Allen-Bradley Co., Milwaukee. In his new position Mr. Dewey will cover Southwestern and Central Michigan and provide sales engineering service for this area.

♦

According to a recent announcement by United States Rubber Co., James E. Power has been named eastern sales manager of the mechanical goods division.

♦

Paul B. Sagar has been named eastern field engineer for General Controls Co., Glendale, Calif., and will work out of the Cleveland factory branch at 3224 Euclid avenue. James King, who formerly handled industrial oil sales for Pure Oil Co. in New York, has been appointed field sales engineer in the New York factory branch of General Controls at 101 Park avenue.

♦

Three new members have been appointed to the staff of the sales department according to a recent announcement by Pacific Division, Bendix Aviation Corp., North Hollywood, Calif. They are: Donald T. Boody, formerly in the engineering and tool design departments, who will serve as liaison en-

NEW MACHINES–

And the Companies Behind Them

Air Conditioning

Precleaner unit for dust collectors, Aget Detroit Co., Ann Arbor, Mich.
Ceiling coolers, Drayer-Hanson Inc., Los Angeles.
Cooling towers, Binks Mfg. Co., Chicago.
Dehumidifier, The General Air Conditioning Co., Cincinnati 9.
*Air conditioner, American Coils Co., Newark, N. J.

Cleaning

Parts cleaning system, Gray Mills Co., Evanston, Ill.

Die Casting

Convertible die casting machine, Kux Machine Co., Chicago 24

Engineering Department

Calculating machine, General Electric Co., Schenectady, N. Y.

Excavating

Earthmoving unit, La Plant-Choate Mfg. Co. Inc., Cedar Rapids, Ia.
Half-yard shovel, Koehring Co., Milwaukee 10.

Food

Blending unit, Sprout, Waldron & Co., Muncy, Pa

Heat Treating

Magnesium preheat furnace, Jas. H. Knapp Co. Inc., Los Angeles 11.
Induction heating 2-station hardening and quench table, Induction Heating Corp., New York 3.
Multipurpose pedestal type furnace, Barkling Fuel Engineering Co., Chicago 22.
All-purpose brazing furnace, Lindberg Engineering Co., Chicago 12.
Electrically-heated furnace, Harold E. Trent Co., Philadelphia 27.

Industrial

Electric portable power grease gun, Alemite Div., Stewart-Warner Corp., Chicago.
Sandblast machine for metals, plastics, etc., Leiman Bros. Inc., Newark 5, N. J.*
Prophylactic fountain for feet, Peda Spray Co. Inc., Seattle.
Magnesium castings baking oven, Genrich Oven Div., W. S. Rockwell Co., New York.

Inspection

X-Ray inspection machine, Kelley-Koett Mfg. Co., Covington, Ky.
Piston ring inspector, The Sheffield Corp., Dayton 1.
*X-Ray Spectrometer, North American Philips Co. Inc., New York.

Instruments

Roll thread comparator with gaging pressure control, Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford, Conn.

Materials Handling

Car puller, American Engineering Co., Philadelphia.
High-weighing-capacity scale, The Yale & Towne Mfg. Co., Philadelphia 24.
Ice crusher-slinger, Link Belt Co., Chicago.

Metalworking

Transfer type 3-station driller, The Cross Co., Detroit 7.
Gear cabinet lathe, Logan Engineering Co., Chicago 30.
500-ton flanging press, Watson-Stillman Co., Roselle, N. J.

*Illustrated on Pages 168, 169.